Specification

Edexcel GCSE in Science: Single Award A (1521) Science: Double Award A (1522)

First examination 2003

November 2000

Edexcel

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Acknowledgements

This specification has been produced by Edexcel on the basis of consultation with teachers, examiners, consultants and other interested parties. Edexcel recognises and values all those who contributed their time and expertise to the development of GCSE specifications.

Authorised by Sue Parker

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Contents

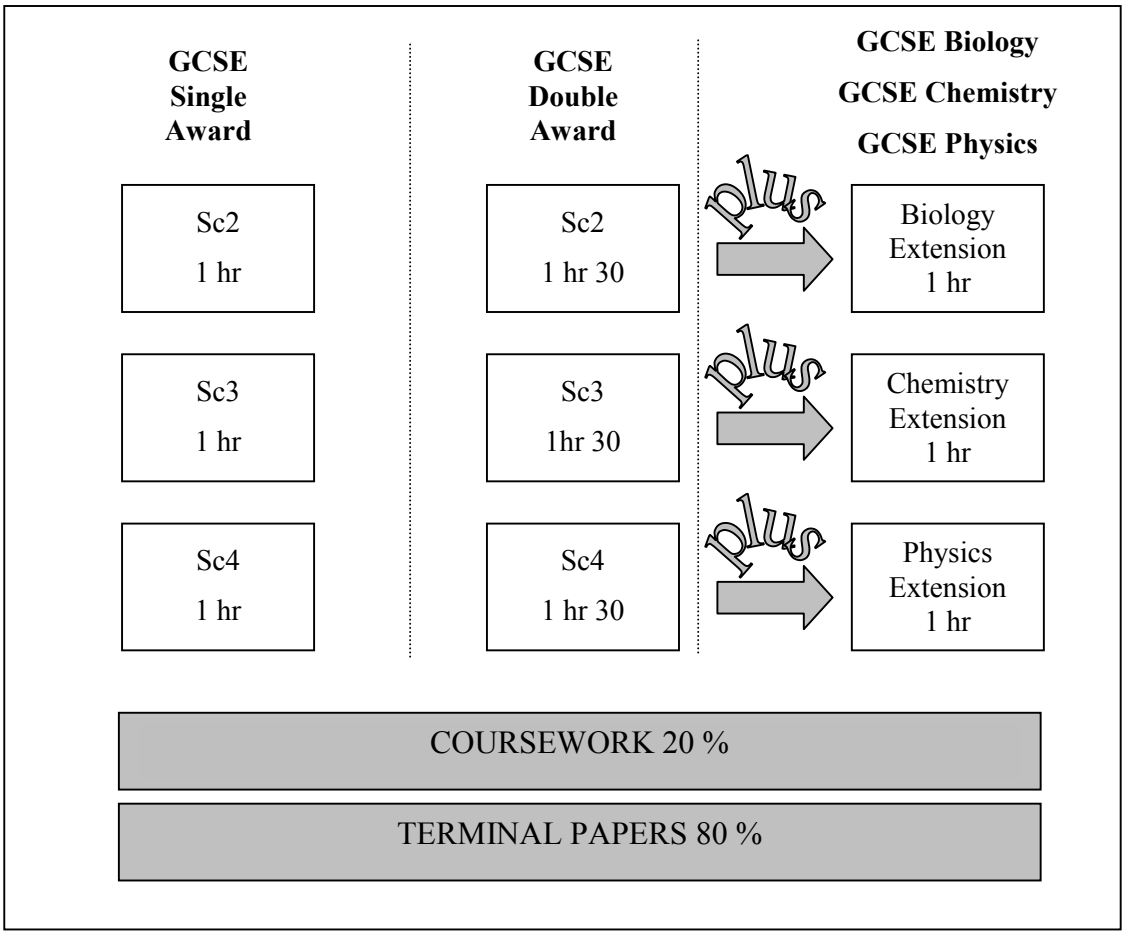
Introduction

The Edexcel GCSEs in Science (linear) are based on the National Curriculum Key Stage 4 programmes of study and offer a linear mode of assessment.

The Single Award specification is a sub-set of the Double Award specification. Further opportunities are given by the direct relationship of the Double Award to the following separate science specifications:

- GCSE in Biology A (1520)
- GCSE in Chemistry A (1530)
- GCSE in Physics A (1540).

The suite of specifications offers flexibility for centres to provide the full range of GCSE qualifications in Science: Single Award, Double Award and the three separate sciences.



The mode of assessment is based on terminal papers, with 20% coursework as a common requirement across the full range of qualifications. Candidates following separate science courses will receive accreditation for GCSE Science: Biology, GCSE Science: Chemistry and GCSE Science: Physics.

Edexcel offers a complementary suite of GCSE Science specifications, with modular assessment, as an alternative:

- Science: Single Award B (1535)
- Science: Double Award B (1536)

Separate sciences

- Biology B (1529)
- Chemistry B (1539)
- Physics B (1549).

Key features

- Suite of specifications permitting a range of accreditation outcomes.
- Clear amplification of subject content.
- Straightforward linear assessment.
- Ideas and evidence in science clearly indicated in the specification and assessment materials.
- Support materials for ideas and evidence relevant to students across the ability range.
- Well-established support strategies for coursework assessment, including free consultancy service for centres.
- Teaching schemes including opportunities for ICT and key skills.
- INSET to cover all aspects of the course.
- Textbooks and on-line resources.

Summary of the specification content

The content is presented in three parts: Life Processes and Living Things, Materials and their Properties, and Physical Processes.

The three parts reflect the content of the National Curriculum Key Stage 4 Science programme of study.

This GCSE specification has been written against the Key Stage 4 Programme of Study for England. Candidates entering for this GCSE in Wales and Northern Ireland must be taught all the material required by the National Curriculum in their own country. The specification content has been signposted where additional material is to be covered in Wales and Northern Ireland.

Double Award

Sc2: Life Processes and Living Things	
B1:	Humans as organisms
B2:	Green plants as organisms
B3:	Variation, inheritance and evolution
B4:	Living organisms in their environment
Sc3: Materials and their Properties	
C1:	Classifying materials
C2:	Changing materials – formulae and equations
C3:	Patterns of behaviour – in elements and compounds
C4:	Changing materials – useful products
C5:	Patterns of behaviour – in reactions
C6:	Changing materials – the environment
Sc4: Physical Processes	
P1:	Electricity and magnetism
P2:	Forces and motion
P3:	Waves
P4:	The Earth and beyond
P5:	Energy resources and energy transfer
P6:	Radioactivity

Single Award

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C5:	Patterns of behaviour – in reactions
Sc4: Physical Processes	
P1:	Electricity and magnetism
P3:	Waves
P4:	The Earth and beyond
P5:	Energy resources and energy transfer
P6:	Radioactivity

Summary of scheme of assessment

Double Award

Paper		Mode of assessment	Weighting	Duration
1F/4H	Sc2 – Life processes and living things	External	25%	1 hr 30 min
2F/5H	Sc3 – Materials and their properties	External	25%	1 hr 30 min
3F/6H	Sc4 – Physical processes	External	25%	1 hr 30 min
	Sc1 – Ideas and evidence in science	*External*	*5%*	*
07	Sc1 – Experimental and investigative skills	Internal	20%	Coursework

*The assessment of the ideas and evidence in science will be evenly spread across the written papers for Sc2, Sc3 and Sc4

Single Award

Paper		Mode of assessment	Weighting	Duration
1F/4H	Sc2 – Life processes and living things	External	25%	1 hr
2F/5H	Sc3 – Materials and their properties	External	25%	1 hr
3F/6H	Sc4 – Physical processes	External	25%	1 hr
	Sc1 – Ideas and evidence in science	*External*	*5%*	*
07	Sc1 – Experimental and investigative skills	Internal	20%	Coursework

*The assessment of the ideas and evidence in science will be evenly spread across the written papers for Sc2, Sc3 and Sc4.

Assessment of scientific enquiry

Ideas and evidence in science

The specification content for both the Double and Single Award has been signposted using the following icon 

to indicate where opportunities arise for the development of ideas and evidence in science. This identifies statements within the specification where candidates might be assessed on:

- how scientific ideas are presented, evaluated and disseminated
- how scientific controversies arise from different ways of interpreting empirical evidence
- ways in which scientific work may be affected by the contexts in which it takes place
- ways of considering the power and limitations of science in addressing industrial, social and environmental questions, including the kinds of questions science can and cannot answer, uncertainties in scientific knowledge and the ethical issues involved.

Centres will be provided with additional support material to help in the teaching of this aspect of the specification.

Scientific enquiry – Sc1

Scientific enquiry may be developed through the context of Life Processes and Living Things (Sc2), Materials and their Properties (Sc3) and Physical Processes (Sc4).

Experimental and investigative skills

In the teaching of this specification, many opportunities will arise for students to carry out investigations, using a range of approaches and selecting appropriate reference sources. The four skill areas to be assessed are:

- (P) planning
- (O) obtaining and presenting evidence
- (A) analysing and considering evidence
- (E) evaluating.

Investigative skills will be internally assessed and externally moderated and contribute 20% of the assessment of the whole qualification. The assessment criteria and requirements for this part of the qualification are common across all awarding bodies.

The coursework submitted for assessment must meet the following requirements.

Award (maximum marks)	**Context**	**Skill area – number of pieces of evidence**				**Maximum number of pieces of work from which marks may be drawn**
		P	O	A	E	
Double (maximum 60 marks)	two from any two of Sc2, Sc3, Sc4	2	2	2	2	4
Single (maximum 30 marks)	one from any one of Sc2, Sc3, Sc4	1	1	1	1	2

Candidates for the Double or Single Award must submit at least one whole investigation.

The minimum requirement for Double Award to satisfy the assessment fully is two pieces of work, which would both be whole investigations from two different contexts in Sc2, Sc3 and Sc4. One of these investigations must be of a practical nature.

The minimum requirement for Single Award to satisfy the assessment fully is one whole practical investigation from any context in Sc2, Sc3 or Sc4.

Further guidance on the assessment and moderation procedures may be found in *Appendix 2*, page 117.

Availability of external assessment

First assessment of this specification will be in June 2003. Assessment will be available in each summer examination session thereafter.

Prior learning and progression

GCSE Science: Double and Single Award A qualifications provide clear progression from the National Curriculum Key Stage 3 programme of study.

The qualifications also offer progression from the Entry Level, Certificate of Achievement in Science. GCSE Science: Double Award A may also be used as a foundation for the following courses:

- GCE AS and Advanced Biology
- GCE AS and Advanced Chemistry
- GCE AS and Advanced Physics
- AVCE Science
- AVCE Health & Social Care
- other science-related courses at level 3.

Forbidden combinations and links with other subjects

Every specification is assigned to a national classification code indicating the subject area to which it belongs.

The classification codes for these specifications are 1310 (Single Award) and 1370 (Double Award).

Centres should be aware that students who enter for more than one GCSE qualification with the same classification code will have only one award (the better) counted for the purpose of the School and College Performance Tables. The Double Award will count as two GCSE qualifications for the purpose of the school and college performance tables.

Candidates entering for this specification may not, in the same series of examinations, enter for any other GCSE specification with the following titles:

- Science: Double Award
- Science: Single Award
- Biology
- Chemistry
- Physics.

The content of this specification complements other level 2 qualifications:

- Foundation or Intermediate GNVQ Health & Social Care
- Foundation or Intermediate GNVQ Land & Environment
- Foundation or Intermediate GNVQ Science
- GCSE Physical Education
- GCSE Geography

- GCSE Mathematics.

Specification aims and assessment objectives

National Qualifications Framework criteria

This specification is based on the common criteria and the GCSE criteria, which are prescribed by the regulatory authorities including QCA and are mandatory for all awarding bodies. It is also derived from the prescribed subject criteria for science.

Aims

This specification gives students opportunities to:

- acquire a systematic body of scientific knowledge, and the skills needed to apply this in new and changing situations in a range of domestic, industrial and environmental contexts
- acquire an understanding of scientific ideas, how they develop, the factors which may affect their development and their power and limitations
- plan and carry out a range of investigations, considering and evaluating critically their own data and that obtained from other sources, and using ICT where appropriate
- evaluate in terms of their scientific knowledge and understanding, the benefits and drawbacks of scientific and technological developments, including those related to the environment, personal health and quality of life, and consider ethical issues
- select, organise and present information clearly and logically, using appropriate scientific terms and conventions, using ICT.

Assessment objectives

This specification requires that all candidates demonstrate the following assessment objectives in the context of the content and skills prescribed. Within each of the assessment objectives the assessment must take account of candidates' ability to communicate clearly and logically, using specialist vocabulary and conventions where appropriate.

AO1 Knowledge and understanding

Candidates must be able to:

- recognise, recall and show understanding of specific scientific facts, terminology, principles, concepts and practical techniques
- demonstrate understanding of the power and limitations of scientific ideas and factors affecting how these ideas develop
- draw on existing knowledge to show understanding of the benefits and drawbacks of applications of science
- select, organise and present relevant information.

AO2 Application of knowledge and understanding, analysis and evaluation

Candidates must be able to:

- describe, explain and interpret phenomena, effects and ideas in terms of scientific principles and concepts, presenting arguments and ideas clearly and logically
- interpret and translate, from one form into another, data presented as continuous prose or in tables, diagrams and graphs
- carry out relevant calculations
- apply principles and concepts to unfamiliar situations, including those related to applications of science in a range of domestic, industrial and environmental contexts
- evaluate scientific information and make informed judgements from it.

AO3 Investigative skills

Candidates must be able to:

- devise and plan investigations, drawing on scientific knowledge and understanding in selecting appropriate strategies
- demonstrate appropriate investigative methods, including safe and skilful practical techniques, obtaining data which are sufficient and of appropriate precision, recording these methodically
- interpret data to draw conclusions which are consistent with the evidence, using scientific knowledge and understanding, whenever possible, in explaining their findings
- evaluate data and methods.

Weighting of assessment objectives

Assessment objective		Weighting
AO1	Knowledge and understanding	45 – 55% (of which about one third for recall)
AO2	Application of knowledge and understanding, analysis and evaluation	25 – 35% (evenly distributed across all aspects of the objective)
AO3	Investigative skills	20 – 25%

Scheme of assessment

Entry tiers

Candidates for this qualification must be entered for one of two tiers. The Higher Tier is targeted at grades A* to D, and the Foundation Tier is targeted at grades C to G. A safety net is provided for candidates entered for the Higher Tier in this specification, and an allowed grade E may be awarded on the Higher Tier. Candidates failing to achieve grade E on the Higher Tier will be reported as Unclassified**.**

Double award

Higher Tier (Grades A*A* to DD)			
Paper 4H	Assessment of Life Processes and Living Things (Sc2)	1 hr 30 min	26.7%
Paper 5H	Assessment of Materials and their Properties (Sc3)	1 hr 30 min	26.7%
Paper 6H	Assessment of Physical Processes (Sc4)	1 hr 30 min	26.7%
Paper 07	Coursework Internal assessment of Experimental and Investigative Science	–	20%

Foundation Tier (Grades CC to GG)			
Paper 1F	Assessment of Life Processes and Living Things (Sc2)	1 hr 30 min	26.7%
Paper 2F	Assessment of Materials and their Properties (Sc3)	1 hr 30 min	26.7%
Paper 3F	Assessment of Physical Processes (Sc4)	1 hr 30 min	26.7%
Paper 07	Coursework Internal assessment of Experimental and Investigative Science	–	20%

The assessment of ideas and evidence in science will be included in all written papers.

Single award

Higher tier (Grades A* to D)			
Paper 4H	Assessment of Life Processes and Living Things (Sc2)	1 hr	26.7%
Paper 5H	Assessment of Materials and their Properties (Sc3)	1 hr	26.7%
Paper 6H	Assessment of Physical Processes (Sc4)	1 hr	26.7%
Paper 07	Coursework Internal assessment of Experimental and Investigative Science	–	20%

Foundation tier (Grades C to G)			
Paper 1F	Assessment of Life Processes and Living Things (Sc2)	1 hr	26.7%
Paper 2F	Assessment of Materials and their Properties (Sc3)	1 hr	26.7%
Paper 3F	Assessment of Physical Processes (Sc4)	1 hr	26.7%
Paper 07	Coursework Internal assessment of Experimental and Investigative Science	–	20%

The assessment of ideas and evidence in science will be included in all written papers.

Written papers

Questions on all written papers will be compulsory. There will be a variety of questions on each paper, including structured questions involving both short answer and extended prose responses. Short answer questions will account for no more than two-thirds of the total credit assigned to externally assessed components. Questions concerning the applications and implications of science will make a significant contribution to the scheme of assessment.

Relationship of assessment objectives to external assessment

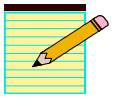
Papers	AO1 %	AO2 %	AO3 %
Each written paper	45-55	25-35	0-5
Paper 07 coursework	0	0	20

Internal assessment

The internal assessment weighting of this specification is 20%. The detailed requirements are set out on pp 4-5 and details of implementation of the scheme start on page 63.

To assist centres to provide all the information required within this document, detailed internal assessment moderation procedures are given in *Appendix 2* on page 117. If it proves necessary to amend these procedures in any way in the future, centres will receive separate notification.

Quality of written communication

The quality of written communication will be assessed in some questions that involve the writing of continuous prose. The mark schemes for questions will take into account the quality of written communication used by candidates in their answers. This will be signposted in the written papers by the following icon 

Candidates will be assessed on their ability to:

- present relevant information in a form that suits its purpose
- ensure that spelling, punctuation and grammar are accurate, so that the meaning is clear
- use a suitable structure and style of writing.

In the assessment of the investigative skills (Sc1) the mark descriptions ensure that the quality of written communication is assessed, based on the agreed common criteria across all awarding bodies.

Quality of written communication will be assessed across all assessment objectives, AO1, AO2 and AO3.

Awarding, reporting and equivalence

The grading, awarding and certification of this specification will comply with the requirements of the GCSE and GCE A/AS Code of Practice for courses starting in September 2001, which is published by QCA. Qualifications will be graded and certificated on an eight-grade scale from A* to G.

GCSEs have broad equivalence to General National Vocational Qualifications in the following terms:

- two GCSEs at grades D to G and two GCSEs at grades A* to C are equivalent to one three-unit GNVQ at Foundation and Intermediate level respectively
- four GCSEs at grades D to G and four GCSEs at grades A* to C are equivalent to one six-unit GNVQ at Foundation and Intermediate level respectively.

Language of assessment

Assessment of this specification will be available in English only. Assessment materials will be published in English only and all written and spoken work submitted for examination and moderation must be produced in English.

Students with particular requirements

Regulations and guidance relating to students with special requirements are published annually by the Joint Council for General Qualifications and are circulated to examinations officers. Further copies of guidance documentation may be obtained from the following address or by telephoning 0870 240 9800.

Edexcel will assess whether or not special consideration or concession can be made for students with particular requirements. Requests should be addressed to:

Special Requirements
Edexcel Foundation
Stewart House
32 Russell Square
London WC1B 5DN

Private candidates

This specification is not available to private candidates.

Specification content – Double Award

Specification content for the Single Award starts on page 44.

In both the Double and Single Award, some content is designated for the **higher tier candidates** only. This content is printed in **bold**.

B1: Humans as organisms

- Cell activity
- Nutrition
- Circulation
- Breathing and respiration
- Nervous coordination
- Hormonal coordination
- Maintaining the internal environment

Cell activity

Candidates will be assessed on their ability to:

- recall that a nucleus, cytoplasm and a cell membrane are present in most animal cells (B1.01)
- understand that substances move into and out of cells through the cell membrane by diffusion; define osmosis in terms of the movement of water molecules from a higher concentration of water to a lower concentration of water through a selectively permeable membrane; interpret data from experiments on osmosis (B1.02)
- **understand that active transport across the cell membrane requires energy to move molecules from a low concentration to a high concentration (B1.03)**
- recognise that the co-ordinated activity of organisms results from the action of cells adapted to different functions; relate the structure of a motor neurone (nerve cell) to its function (B1.04)

Nutrition

In order to meet statutory requirements, candidates following the Welsh National Curriculum should be taught how the presence of starch, sugar and protein in foods can be detected by testing.

Candidates will be assessed on their ability to:

- describe the functions of the mouth, oesophagus (gullet), stomach, small and large intestines, pancreas, liver and gall bladder (B1.05)
- understand the role of the muscular wall of the gut in peristalsis (B1.06)
- explain how the structure of villi (large surface area, single layer of cells and capillary network) allows efficient absorption of the soluble products of digestion (B1.07)

- understand the role of bile and of digestive enzymes: bile neutralises stomach acid and emulsifies fats; amylase digests starch to simple sugars; proteases (eg pepsin) digest proteins to amino acids; lipase digests fats to fatty acids and glycerol (B1.08)
- understand that enzymes are sensitive to temperature and pH; interpret data from experiments relating to digestion (B1.09)

Circulation

Candidates will be assessed on their ability to:

- describe the composition of blood: plasma, red blood cells, white blood cells and platelets (B1.10)
- understand the roles of these components in: the transport of oxygen, nutrients, carbon dioxide, urea, hormones and thermal energy (heat); combating infection, including the ingestion of micro-organisms and the production of antibodies which destroy micro-organisms; blood clotting (to prevent blood loss and entry of micro-organisms) (B1.11)

- relate the structure of the heart to its function as a pump, including the roles of atria and ventricles, the valves in the heart and the coronary vessels (B1.12)
- relate the structure of arteries, veins and capillaries to their functions (B1.13)
- understand that substances, including oxygen, carbon dioxide, glucose and urea, are exchanged by diffusion between capillaries and tissues (B1.14)
- recall the plan of the double circulatory system, including aorta, vena cava and blood vessels, to and from lungs, kidneys and liver (B1.15)

Breathing and respiration

Candidates will be assessed on their ability to:

- describe the structure of the thorax including ribs, intercostal muscles, diaphragm, trachea, bronchi, bronchioles, alveoli and pleural membranes (B1.16)
- explain the role of the intercostal muscles and diaphragm in ventilating the lungs (B1.17)
- understand the similarities and differences between aerobic and anaerobic respiration; recall the word equation for anaerobic respiration in animal cells: glucose → lactic acid and energy released (B1.18)

- explain how vigorous exercise can result in an oxygen debt (B1.19)

Nervous coordination

Candidates will be assessed on their ability to:

- recall that the central nervous system (brain and spinal cord) is linked to sense organs by nerves (B1.20)
- understand that stimulation of receptors in the sense organs sends electrical impulses along nerves into and then out of the central nervous system, resulting in rapid responses; describe the differences between voluntary and reflex responses (B1.21)
- **describe the pathway taken by electrical impulses along a sensory neurone, a relay neurone and a motor neurone to an effector (muscle or gland); understand the role of transmitter chemicals at synapses; explain the removal of a finger from a hot object (B1.22)**

- describe the role of the iris and pupil, retina and optic nerve in the iris reflex (B1.23)
- **explain the role of cornea, ciliary body, suspensory ligaments and lens in forming sharp images of near and distant objects on the retina (B1.24)**

Hormonal coordination

Candidates will be assessed on their ability to:

- define hormones as chemicals released directly into the blood from glands: insulin from the pancreas, testosterone from the testes, oestrogen from the ovaries, progesterone from the ovaries and placenta, follicle stimulating hormone (FSH) and lutenising hormone (LH) from the pituitary gland (B1.25)
- explain the role of insulin in regulating the level of blood sugar and its use in treating diabetes (B1.26)
- describe the roles of oestrogen and testosterone in promoting secondary sexual characteristics and the production of gametes (B1.27)
- explain:
  - the role in the menstrual cycle of FSH, oestrogen, LH and progesterone
  - the use of sex hormones in the control and promotion of fertility (B1.28)
- **describe the roles of adrenaline, released from the adrenal glands, in preparing the body for increased activity (B1.29)**

Maintaining the internal environment

Candidates will be assessed on their ability to:

- define homeostasis as the maintenance of a constant internal environment and understand why this is important (B1.30)
- explain how sweating and shivering help to maintain constant body temperature (B1.31)
- **explain the role of vasodilation and vasoconstriction in temperature regulation (B1.32)**
- recall that carbon dioxide is removed by the lungs in exhaled air (B1.33)
- recall that urea is removed by the kidneys in urine (B1.34)
- **describe the structure of a nephron to include Bowman's (renal) capsule and glomerulus, coiled tubules, collecting duct, arterioles and capillaries (B1.35)**
- **describe:**
  - **ultrafiltration in Bowman's capsule**
  - **the composition of glomerular filtrate**
  - **reabsorption in the coiled tubules (B1.36)**
- **explain the role of ADH in regulating the water content of the blood (B1.37)**
- understand the roles of skin, stomach acid and blood in defending the body against infection (B1.38)

- understand the role of the mucous membranes of the respiratory tract in defending the body against infection (B1.39)
- describe the harmful effects of:
  - solvents on the lungs and neurones
  - alcohol on reaction times, behaviour, liver and brain
  - smoking tobacco on the occurrence of bronchitis, emphysema, lung cancer and addiction to nicotine (B1.40)

- evaluate the use and misuse of drugs, including antibiotics (eg penicillin), pain killers (eg aspirin and heroin), stimulants (eg caffeine and amphetamines), sedatives (eg barbiturates) and the dangers of contracting HIV and hepatitis by the use of intravenous drugs (B1.41)

B2: Green plants as organisms

- Cell activity
- Nutrition
- Water relations and transport
- Control of growth

Cell activity

Candidates will be assessed on their ability to:

- recall that a plant cell has a nucleus, cytoplasm and a cell membrane; it also has a cellulose cell wall, a large vacuole and (in green parts of plants) chloroplasts (B2.01)
- recognise that the co-ordinated activity of organisms results from the adaptation of cells to different functions; relate the structure of a palisade leaf cell to its function (B2.02)

Nutrition

Candidates will be assessed on their ability to:

- understand that carbon dioxide and water are converted to glucose and oxygen by photosynthesis using sunlight energy absorbed by chlorophyll, the green pigment contained in chloroplasts (B2.03)
- understand that carbon dioxide from the atmosphere diffuses in through stomata and oxygen diffuses out as a result of photosynthesis (B2.04)
- **explain the pattern of gas exchange between a plant and the atmosphere resulting from photosynthesis and respiration over a 24 hour period (B2.05)**

- describe how the rate of photosynthesis varies with carbon dioxide concentration, light intensity and temperature; interpret data from experiments relating to photosynthesis (B2.06)
- understand that plants use the glucose produced by photosynthesis for respiration to release energy, for conversion to starch for storage and to cellulose for cell walls, and as a component in protein synthesis (B2.07)
- understand the need for mineral ions for healthy plant growth, including nitrates for protein synthesis and magnesium for chlorophyll; interpret data from water culture experiments (B2.08)

Water relations and transport

Candidates will be assessed on their ability to:

- explain how water is taken in by osmosis (B2.09)
- understand the role of water in maintaining cell turgidity to support plant tissues (B2.10)
- **explain the uptake of mineral ions by active transport (B2.11)**
- recall that the substances required for growth and reproduction are transported within plants in xylem (water and mineral ions) and in phloem (sugars and amino acids) (B2.12)

- understand how leaf structure (shape, cuticle, palisade layer, spongy layer, veins, guard cells and stomata) is adapted for photosynthesis and transpiration (B2.13)
- explain how leaves lose water by transpiration, including the evaporation of water within the leaf and diffusion of water vapour through stomata; interpret data from experiments relating to transpiration (B2.14)
- describe how atmospheric conditions affect the rate of transpiration (B2.15)

Control of growth

Candidates will be assessed on their ability to:

- recall that auxins influence cell division and the elongation of cells at the tips of roots and shoots (B2.16)
- describe commercial applications of plant hormones: stimulating the growth of roots in cuttings; regulating the development of fruits; killing weeds by disrupting their normal growth pattern (B2.17)

B3: Variation, inheritance and evolution

- Variation
- Inheritance
- Evolution

Variation

Candidates will be assessed on their ability to:

- recall that the nucleus of a cell contains chromosomes on which genes (units of inherited information) are located (B3.01)
- understand that each gene is a section of a molecule of DNA (B3.02)
- describe a DNA molecule as two strands coiled to form a double helix, the strands being linked by a series of paired bases (adenine with thymine and cytosine with guanine) (B3.03)
- understand that:
  - variation between individuals arises from genetic and environmental causes and from a combination of both
  - environmental conditions during growth and development cause variation between genetically identical individuals (B3.04)
- understand:
  - that genes exist in alternative forms (alleles) which cause variation in inherited characteristics
  - the terms dominant and recessive
  - that some alleles cause diseases which can be inherited (B3.05)
- recall that:
  - chromosomes are present as pairs in body cells and singly in gametes
  - 46 and 23 are the diploid and haploid numbers of chromosomes in human cells (B3.06)
- **understand that division of a cell by mitosis produces two cells which contain identical sets of chromosomes for growth and replacement; interpret diagrams showing the overall behaviour of chromosomes during mitosis (technical terms not required) (B3.07)**
- **understand that division of a cell by meiosis produces four cells, each with half the number of chromosomes for the formation of genetically different haploid gametes during sexual reproduction; interpret simple diagrams and photographs showing stages in meiosis (technical terms not required) (B3.08)**
- define fertilisation as the fusion of haploid male and female gametes, restoring the diploid number of chromosomes in the zygote; explain the resulting genetic variation in the new generation of individuals (B3.09)
- explain that asexual reproduction involves only one parent and gives rise to genetically identical offspring (clones) (B3.10)

- recall that a mutation is a change in a gene, DNA or the number of chromosomes in a cell, which leads to genetic variation (B3.11)

- understand that many mutations are harmful, some are neutral and a few are beneficial and can increase in the population by natural selection (B3.12)
- understand that exposure to ionising radiation (including gamma rays, ultraviolet rays and X-rays) and some chemical mutagens (including chemicals in tobacco) increase the incidence of mutations (B3.13)

Inheritance

Candidates will be assessed on their ability to:

- recall that the sex of a person is controlled by one pair of chromosomes, XX in a female or XY in a male, and describe the determination of the sex of offspring at fertilisation, using a genetic diagram (B3.14)
- describe the mechanism of monohybrid inheritance using a crossing diagram (B3.15)
- **understand how individuals can be homozygous or heterozygous for particular alleles; distinguish between genotype and phenotype (B3.16)**
- **predict probabilities of inheritance from parents using genetic diagrams (B3.17)**
- **explain family trees showing the inheritance of polydactyly (dominant allele) and cystic fibrosis (recessive allele) (B3.18)**

- describe some of the implications of the outcome of the Human Genome Project (B3.19)
- describe how selective breeding is used to develop crop plants and agricultural animals with desirable characteristics such as resistance to disease and high yields (B3.20)
- understand that cloning is used to produce large numbers of identical individuals with desirable characteristics (eg plant cuttings) (B3.21)

- describe the ethical implications of selective breeding and cloning (B3.22)

- **describe how the transfer of a required gene from a donor to a recipient, including the use of restriction enzymes and ligase, can produce genetically modified organisms (B3.23)**
- **evaluate the ethical implications of genetic modification (B3.24)**

Evolution

Candidates will be assessed on their ability to:

- understand that fossils provide evidence of evolution (B3.25)
- describe how inherited variation can lead to evolution or extinction by the process of natural selection (B3.26)

B4: Living organisms in their environment

- Humans and the environment
- Ecosystems

Humans and the environment

Candidates will be assessed on their ability to:

- understand the principles of interdependence, adaptation, competition and predation; explain how these factors influence the distribution and population sizes of organisms in a given terrestrial or aquatic environment (B4.01)

- describe the impact of human activity on the environment, including the pollution of air and of water; recall the effects of air pollutants (eg sulfur dioxide, carbon monoxide) and of water pollutants (eg sewage, nitrates and phosphates) (B4.02)
- relate the level of impact on the environment to population size, economic factors and industrial requirements (B4.03)
- describe the effects of deforestation and overfishing; understand the importance of protecting natural populations (B4.04)

Ecosystems

Candidates will be assessed on their ability to:

- describe food chains quantitatively using pyramids of biomass (B4.05)
- understand that energy is transferred through food chains and that energy and biomass are lost between trophic levels (B4.06)
- understand that energy transfer can be maximised in food production, for example in fish farms (B4.07)

- **explain the techniques used to maximise food production in terms of optimum feeding conditions, disease and predator control (B4.08)**
- describe the stages in the carbon cycle, including the roles of micro-organisms; interpret carbon cycle diagrams (B4.09)
- **describe the stages in the nitrogen cycle, including the roles of nitrogen-fixing bacteria, decomposers, nitrifying bacteria and denitrifying bacteria (specific names of bacteria are not required); interpret nitrogen cycle diagrams (B4.10)**

C1: Classifying materials

- Atomic structure
- Bonding

Atomic structure

Candidates will be assessed on their ability to:

- describe the structure of an atom as a nucleus containing protons and neutrons, surrounded by orbiting electrons arranged in shells (C1.01)
- recall the relative mass and relative charge of a proton, a neutron and an electron (C1.02)
- understand the terms atomic number, mass number and relative atomic mass (C1.03)
- describe the electronic structures of the first twenty elements in the periodic table in terms of numbers of electrons in electron shells, given the atomic numbers (C1.04)
- explain the existence of isotopes (C1.05)
- **calculate the relative atomic mass of an element from relative masses and abundances of its isotopes (C1.06)**

Bonding

Candidates will be assessed on their ability to:

- understand that atoms of different elements can combine to form compounds by the formation of new chemical bonds (C1.07)
- understand that ionic bonds can be made by the transfer of electrons to form cations and anions (C1.08)
- describe the formation of Na^+ and Cl^- ions and hence the formation of ions in other ionic compounds from their atoms (C1.09)
- describe and explain the physical properties of giant ionic structures, including sodium chloride and magnesium oxide (C1.10)
- understand that covalent bonds can be made by electron sharing to form molecules (C1.11)
- describe the formation, including dot and cross diagrams, of simple molecules including H_2, HC1, H_2O **and CO_2** (C1.12)
- describe and explain the physical properties of simple molecular substances (C1.13)

- **understand that covalent bond formation can also result in giant structures including diamond and graphite (C1.14)**
- **describe and explain the physical properties of giant covalent structures including diamond and graphite (C1.15)**
- **explain the difference between properties of simple molecular substances and giant covalent substances (C1.16)**

C2: Changing materials – formulae and equations

- Representing reactions

Representing reactions

Candidates will be assessed on their ability to:

- represent chemical reactions by word equations (C2.01)
- recall the formulae of elements and simple compounds in the specification (C2.02)
- calculate relative formula mass from relative atomic masses (C2.03)
- write simple balanced equations (C2.04)
- use the state symbols (s), (l), (g) and (aq) (C2.05)
- **write balanced equations to describe and explain a wide range of reactions including ionic equations and those occurring in electrolytic cells (C2.06)**
- **determine the formulae of simple compounds from reacting masses and understand that these are empirical (C2.07)**
- **use chemical equations to calculate masses of reactants and products (C2.08)**

C3: Patterns of behaviour – in elements and compounds

- The periodic table
- Noble gases
- Alkali metals
- Halogens
- Transition metals
- Chemicals from salt
- Chemicals from calcium carbonate

The periodic table

Candidates will be assessed on their ability to:

- recall that there are approximately 100 elements and that all materials are composed of one or more of these (C3.01)
- understand that the periodic table shows elements in order of increasing atomic number, arranged in rows (periods) (C3.02)
- recall that elements with similar properties appear in the same vertical column (group) (C3.03)
- recall the positions of the alkali metals (group 1), the halogens (group 7), the noble gases (group 0) and the transition metals in the periodic table (C3.04)
- understand the connection between the number of outer electrons and the position of an element in the periodic table (C3.05)
- understand that the reactions of elements depend upon the arrangement of electrons in their atoms (C3.06)
- recall that there is a gradual change in the properties of the elements from the top to the bottom of each group (C3.07)

Noble gases

Candidates will be assessed on their ability to:

- relate the uses of noble gases to their physical properties and lack of chemical reactivity (C3.08)
- explain the monatomic nature of noble gases (C3.09)

Alkali metals

Candidates will be assessed on their ability to:

- recall that the alkali metals have comparatively low melting points and boiling points and are softer than other metals (C3.10)
- describe the relative reactivity of the alkali metals as exemplified by their reaction with water (C3.11)
- recall that common compounds of the alkali metals are soluble in water and that the oxides and hydroxides of the alkali metals are alkaline (pH>7) (C3.12)

Halogens

Candidates will be assessed on their ability to:

- recall the colours and physical states of the halogens at room temperature (C3.13)
- recall that halogens react with metals to form metal halides (C3.14)
- recall that halogens react with hydrogen to produce hydrogen halides which dissolve in water to form acidic solutions (pH<7) (C3.15)
- describe the relative reactivity of the halogens as exemplified by their displacement reactions with halide ions in aqueous solution (C3.16)
- describe the use of fluorides in the water supply and in toothpaste, of chlorine in water purification and of iodine as an antiseptic (C3.17)

Transition metals

Candidates will be assessed on their ability to:

- recall that transition metal compounds are generally coloured (C3.18)
- recall the use of transition metals and their compounds as catalysts (C3.19)
- relate the uses of titanium, iron and copper to their properties (C3.20)

Chemicals from salt

Candidates will be assessed on their ability to:

- recall that hydrogen, chlorine and sodium hydroxide are produced by the electrolysis of concentrated aqueous sodium chloride and know how to test for these substances (C3.21)
- describe the uses of sodium chloride, hydrogen, chlorine and sodium hydroxide (C3.22)

Chemicals from calcium carbonate

Candidates will be assessed on their ability to:

- describe the thermal decomposition of calcium carbonate to make calcium oxide and carbon dioxide (C3.23)
- describe the effect of water on calcium oxide and appreciate that the solution produced is lime water (C3.24)
- understand why calcium oxide and calcium hydroxide are used to neutralise soil acidity (C3.25)
- recall that calcium carbonate is used in the production of glass, cement and iron (C3.26)

C4: Changing materials – useful products

- Extraction and uses of metals
- Useful products from crude oil

Extraction and uses of metals

Candidates will be assessed on their ability to:

- define oxidation in terms of gain of oxygen and reduction in terms of loss of oxygen (C4.01)
- **define oxidation in terms of loss of electrons and reduction in terms of gain of electrons (C4.02)**
- understand that the extraction of metals involves reduction of their ores (C4.03)

- recall how the way in which a particular metal is extracted from its ores is related to its position in the reactivity series (C4.04)
- understand that processes involving the use of large amounts of electricity are relatively expensive (C4.05)
- describe the extraction of aluminium from purified bauxite including simple cell diagram, nature of electrolyte and electrodes, and reactions (C4.06)
- relate the uses of aluminium to its properties (C4.07)
- recall that carbon and carbon monoxide can reduce the oxides of less reactive metals (C4.08)
- describe the extraction of iron in the blast furnace, including outline diagram, raw materials, reactions and the formation and uses of slag (C4.09)
- describe the purification of copper by electrolysis, including a simple diagram of the cell (C4.10)

Useful products from crude oil

Candidates will be assessed on their ability to:

- recall that hydrocarbons contain carbon and hydrogen only and that crude oil is a mixture of hydrocarbons (C4.11)
- describe the fractional distillation of crude oil (C4.12)
- understand that the larger the hydrocarbon molecule, the higher the boiling point of the hydrocarbon and the less volatile it is at a given temperature (C4.13)
- recall the uses of the main fractions (gases, petrol, naphtha, kerosene, diesel oil, fuel oil, bitumen) (C4.14)

- recall and explain the formation of the products of the complete and incomplete combustion (oxidation) of hydrocarbons, and the possible effect of these on the environment (C4.15)
- describe how to test for carbon dioxide (using lime water) and water (using cobalt chloride) (C4.16)

- **explain that cracking involves the breaking down of larger hydrocarbon molecules into smaller, more useful ones, some of which have carbon-carbon double bonds (C4.17)**
- **describe the conditions used in industry to crack fractions obtained from crude oil (C4.18)**
- **recall that, when alkanes are cracked, mixtures of alkanes and alkenes are formed (C4.19)**
- **explain that alkanes are saturated hydrocarbons and that alkenes are unsaturated hydrocarbons (C4.20)**
- recall that methane is the main constituent of natural gas (C4.21)
- recall the formulae of methane, ethane, propane and butane (not methyl propane) and draw the structures of these molecules (C4.22)
- **recall the formulae of ethene and propene and draw the structures of their molecules (C4.23)**
- **describe how bromine water is used to distinguish between alkanes and alkenes (C4.24)**
- recall that polymers are large molecules which can be formed by a combination of many smaller molecules (C4.25)
- **explain how addition polymers are formed from unsaturated monomers (equations required but not conditions and mechanisms) (C4.26)**

- describe the uses and associated properties of poly(ethene), poly(propene) and poly(chloroethene) (C4.27)

C5: Patterns of behaviour – in reactions

- Rates of reaction
- Energy transfers accompanying reactions

Rates of reaction

Candidates will be assessed on their ability to:

- recall that the rates of chemical reactions vary from very fast, explosive reactions to very slow reactions which form no detectable products (C5.01)
- describe experiments to investigate the effect of temperature, concentration and surface area of a solid on the rate of a reaction (C5.02)
- interpret the results of such experiments (C5.03)
- recall and explain the effect of changes in temperature, concentration and surface area of a solid on a given rate of reaction (C5.04)
- understand that reactions can occur when particles collide and that increasing the frequency and energy of collisions increases the rate of the reaction (C5.05)

- describe the effect of a catalyst on a given rate of reaction (C5.06)
- define enzymes as catalysts in biological systems and describe their use in washing powder, and food and drink manufacture (C5.07)
- describe how the rates of enzyme-catalysed reactions vary with temperature and pH (C5.08)

Energy transfers accompanying reactions

Candidates will be assessed on their ability to:

- recall that changes of temperature often accompany reactions (C5.09)
- define an exothermic reaction as one in which heat energy is given out, and give examples (C5.10)
- define an endothermic reaction as one in which heat energy is taken in, and give examples (C5.11)
- **recall that the breaking of bonds is endothermic and that the making of bonds is exothermic (C5.12)**

C6: Changing materials – the environment

- Manufacture of ammonia and fertilisers
- The Earth and its atmosphere

Manufacture of ammonia and fertilisers

Candidates will be assessed on their ability to:

- describe the conditions under which ammonia is produced from nitrogen and hydrogen in the Haber process (C6.01)
- understand that this reaction is reversible and may reach a dynamic equilibrium (C6.02)
- **understand how the position of a dynamic equilibrium is affected by changes of temperature and pressure, to include the Haber process as an example (C6.03)**
- **understand the consequential effects of these changes on the rate of attainment of equilibrium and the need to use a catalyst (C6.04)**
- recall that a nitrogenous fertiliser is manufactured by neutralising ammonia with nitric acid (C6.05)
- recall that nitrogenous fertilisers promote plant growth (C6.06)
- understand that the process of leaching of artificial fertilisers causes excessive plant growth in rivers and lakes and may be harmful to health (C6.07)

The Earth and its atmosphere

Candidates will be assessed on their ability to:

- describe the composition of the atmosphere (C6.08)
- understand that the Earth's early atmosphere was probably formed from the gases produced by volcanic activity (C6.09)
- recall that originally the atmosphere probably contained a large amount of carbon dioxide together with water vapour, hydrogen, nitrogen and carbon monoxide (C6.10)
- explain the origin of the oceans by condensation of water vapour and describe how the percentage of carbon dioxide in the atmosphere was consequently reduced (C6.11)
- explain that the first primitive plants released oxygen as a result of photosynthesis and that the percentage of oxygen in the atmosphere gradually increased (C6.12)
- explain how the carbon cycle helps to maintain atmospheric composition, ie carbon dioxide is added to the atmosphere by respiration and combustion and removed by photosynthesis and dissolving in water (C6.13)
- understand that the crystalline nature of igneous rocks and the fact that they do not contain fossils are evidence for their formation from hot, molten magma (C6.14)
- understand that crystal size in igneous rocks depends on the rate of cooling (C6.15)

- understand that the presence of fossils in a rock is evidence that it has been formed from sediments (C6.16)
- understand that in sedimentary rocks the deepest layers are usually the oldest, that sedimentary rocks may contain fossils, and that the type of fossil can help to date the rocks (C6.17)
- explain how metamorphic rocks are formed by the action of heat and pressure on existing rocks (C6.18)
- understand that metamorphic rocks having the same composition as other rocks is evidence for their formation from these rocks – eg marble and limestone are both calcium carbonate (C6.19)

P1: Electricity and magnetism

- Units
- Mains electricity
- Energy and potential difference in circuits
- Electric charge
- Electromagnetism
- Electromagnetic induction

Units

Candidates will be assessed on their ability to:

- use the following units: ampere (A), coulomb (C), ohm (Ω), volt (V), watt (W), kilowatt-hour (kW h) (P1.01)

Mains electricity

Candidates will be assessed on their ability to:

- identify the live, neutral and earth conductor in a correctly-wired plug and recall the colour of the insulation used on each conductor (P1.02)
- recall the hazards of electricity including frayed cables, long cables, damaged plugs, water around sockets and pushing metal objects into sockets (P1.03)
- describe the uses of insulation, double insulation, earthing, fuses and circuit breakers in a range of domestic appliances (P1.04)
- recall that electrical heating is used in a variety of ways in domestic contexts (P1.05)
- understand that a current in a resistor results in the electrical transfer of energy and an increase in temperature (P1.06)
- recall and use the quantitative relationship between power, current and voltage:
  power = current × voltage $P = I \times V$
  and apply the above relationship to the selection of appropriate fuses (P1.07)
- calculate the energy used by domestic appliances in kilowatt-hours and calculate domestic electricity bills, based on meter readings (P1.08)
- **use the quantitative relationship between energy transferred, current, voltage and time:**
  energy transferred = current × voltage × time $E = I \times V \times t$ **(P1.09)**
- recall that mains electricity is alternating current (a.c.) and understand the difference between this and the direct current (d.c.) supplied by a cell (P1.10)

Energy and potential difference in circuits

Candidates will be assessed on their ability to:

- explain whether a series or parallel circuit is more appropriate for a range of applications, including domestic lighting (P1.11)
- understand that the current in a series circuit depends on the applied voltage and the number and nature of other components (P1.12)
- describe how current varies with voltage in wires, resistors, metal filament lamps and diodes and how this can be investigated experimentally (P1.13)

- describe the qualitative effect of changing resistance on the current in a circuit (P1.14)
- describe the qualitative variation of resistance of LDRs with illumination and of thermistors with temperature (P1.15)
- recall and use the quantitative relationship between voltage, current and resistance: voltage = current × resistance $V = I \times R$ (P1.16)
- understand that current is rate of flow of charge (P1.17)
- recall and use the quantitative relationship between charge, current and time: charge = current × time $Q = I \times t$ (P1.18)
- **recall electric current in solid metallic conductors is a flow of negatively charged electrons (P1.19)**
- **recall that electric current in molten or dissolved electrolytes is a flow of negatively charged ions to the positive terminal and positively charged ions to the negative terminal (P1.20)**
- **recall that:**
  - **voltage is the energy transferred per unit charge passed**
  - **a volt is a joule per coulomb (P1.21)**

Electric charge

Candidates will be assessed on their ability to:

- describe common materials which are electrical conductors or insulators including metals and plastics (P1.22)
- recall that insulating materials can be charged by friction (P1.23)
- explain that positive and negative electrostatic charges are produced on materials by the loss and gain of electrons (P1.24)
- recall that there are forces of attraction between unlike charges and repulsion between like charges (P1.25)
- explain common electrostatic phenomena, including shocks from car doors and synthetic fabrics, in terms of the movement of electrons (P1.26)
- describe the potential dangers and uses of electrostatic charges generated in everyday situations, eg fuelling aircraft and tankers, photocopiers and inkjet printers (P1.27)

Electromagnetism

Candidates will be assessed on their ability to:

- recall that a force is exerted on a current-carrying wire in a magnetic field and the application of this effect in simple d.c. electric motors and loudspeakers (P1.28)
- understand that when a wire carrying a current is perpendicular to a magnetic field, the resulting force is perpendicular to both (P1.29)

Electromagnetic induction

Candidates will be assessed on their ability to:

- recall that a voltage is induced in a conductor when it moves through a magnetic field or when a magnetic field changes through a coil, and recall the factors which affect the size of the induced voltage (P1.30)
- describe the generation of electricity by the rotation of a magnet within a coil of wire and of a coil of wire within a magnetic field and the factors which affect the size of the induced voltage (P1.31)
- recall the structure of a transformer and understand that a transformer changes the size of an alternating voltage by having different numbers of turns on the input and output sides (P1.32)
- describe the use of step-up and step-down transformers in the large-scale transmission of electrical energy (P1.33)
- **recall and use the quantitative relationship between input (primary) and output (secondary) voltages and the turns ratio for a transformer:**

$$\frac{\text{voltage(primary)}}{\text{voltage(secondary)}} = \frac{\text{turns(primary)}}{\text{turns(secondary)}}$$

$$\frac{V_P}{V_S} = \frac{n_P}{n_S} \quad \textbf{(P1.34)}$$

P2: Forces and motion

- Units
- Movement and position
- Forces and shape

Units

Candidates will be assessed on their ability to:

- use the following units: kilogram (kg), metre (m), metre^2 (m^2), metre^3 (m^3), metre/second (m/s), metre/second^2 (m/s^2), newton (N), pascal (Pa) (P2.01)

Movement and position

Candidates will be assessed on their ability to:

- understand distance – time graphs (P2.02)
- explain the difference between speed and velocity (P2.03)
- recall and use the quantitative relationship between acceleration, velocity and time:

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time taken}} \qquad a = \frac{(v - u)}{t} \qquad \text{(P2.04)}$$

- interpret speed-time graphs and determine acceleration from the gradient of the graph (P2.05)
- **determine the distance travelled from the area between the curve and the time axis (P2.06)**

Forces and movement

Candidates will be assessed on their ability to:

- recall a brief history of our understanding of forces including:
  - the Greek view – a single force needed to sustain motion
  - Galileo and Newton – balanced forces allow an object to continue in uniform motion in a straight line or to remain at rest
  - Newton – gravitational attraction acts between all masses (P2.07)
- recall that when two bodies interact, the forces they exert on each other are equal and opposite (P2.08)
- understand how to add forces which act along a line (P2.09)
- understand that friction can produce both accelerating and retarding forces (P2.10)
- **recall and use the quantitative relationship between unbalanced force, mass and acceleration and apply this relationship to vehicular and human movement:**

  force = mass × acceleration

  $\boldsymbol{F = m \times a}$ **(P2.11)**
- recall and use the quantitative relationship between weight, mass and *g*:
  weight = mass × *g* $W = m \times g$ (P2.12)

- recall that a mass of 1 kg has a weight of 10 N on Earth; ie the Earth's gravitational field strength is 10 N/kg (P2.13)
- explain the forces acting on falling objects and why falling objects reach a terminal velocity (P2.14)
- understand that the stopping distance of a vehicle is the sum of the thinking distance and the stopping distance (P2.15)
- describe the factors affecting vehicle stopping distances including speed, mass, road condition and reaction time (P2.16)

Forces and shape

In order to meet statutory requirements, candidates following the Welsh National Curriculum should be taught the principle of moments and its application to situations involving one pivot.

Candidates will be assessed on their ability to:

- understand that the upward forces on a light beam supported at its ends vary with the position of a heavy object placed on the beam (P2.17)
- describe how extension varies with applied force for a range of materials including springs and/or rubber bands (P2.18)

- recall that particles in a gas have random motion and that they exert a force on the walls of the container (P2.19)
- **understand the relationship between the pressure and volume of a fixed mass of gas at constant temperature and use the quantitative relationship**

  $P_1 \times V_1 = P_2 \times V_2$ **(P2.20)**

P3: Waves

- Units
- Properties of waves
- The Earth's layered structures
- The electromagnetic spectrum
- Light and sound

Units

Candidates will be assessed on their ability to:

- use the following units: hertz (Hz), kilohertz (kHz), megahertz (MHz), metre/second (m/s) (P3.01)

Properties of waves

Candidates will be assessed on their ability to:

- describe longitudinal and transverse waves in ropes, springs and water (P3.02)
- state the meaning of amplitude, frequency, wavelength and period of a wave (P3.03)
- recall that waves transfer energy and information without transferring matter (P3.04)
- recall and use the quantitative relationship between the speed, frequency and wavelength of a wave:
  speed = frequency × wavelength $v = f \times \lambda$ (P3.05)
- use the quantitative relationship between frequency and time period:

  $$\text{frequency} = \frac{1}{\text{time period}} \quad f = \frac{1}{T} \quad \text{(P3.06)}$$

- use the above relationships in a wide range of contexts including sound waves and electromagnetic waves (P3.07)
- understand that waves can be diffracted through gaps or when they pass an edge and that the extent of diffraction depends on the wavelength and the physical dimension (P3.08)

The Earth's layered structure

Candidates will be assessed on their ability to:

- **understand that the different ways in which longitudinal and transverse waves are transmitted through the Earth, and their paths and times of travel, provide evidence for the Earth's layered structure: crust, mantle, outer (liquid) core, inner core (P3.09)**
- recall that the Earth's outermost layer, the lithosphere, is composed of plates in relative motion and that plate tectonic processes result in the formation, deformation and recycling of rocks (P3.10)

- understand that at plate boundaries, plates may:
  - slide past each other, causing earthquakes
  - move towards each other, taking rock into the mantle
  - move away from each other, resulting in volcanoes and/or formation of new rocks (P3.11)

The electromagnetic spectrum

Candidates will be assessed on their ability to:

- understand that light is part of a continuous electromagnetic spectrum which includes radio, microwave, infra-red, visible, ultraviolet, X-ray and gamma ray radiations and that all these waves travel at the same speed in free space (P3.12)
- recall the order of the electromagnetic spectrum in decreasing wavelength and increasing frequency, including the colours of the visible spectrum (P3.13)
- recall some uses of electromagnetic radiations including:
  - radio waves: broadcasting and communications
  - microwaves: cooking and satellite transmissions
  - infra-red: heaters, grills, night vision and remote controls
  - visible light: optical fibres and photography
  - ultraviolet: sunbeds, crime prevention and fluorescent lamps
  - X-rays: observing the internal structure of objects and materials, medical applications
  - gamma rays: sterilising food and medical equipment (P3.14)
- recall the detrimental effects of excessive exposure of the human body to electromagnetic waves of increasing frequencies including:
  - microwaves: internal heating of body tissue
  - infra-red: skin burns
  - ultraviolet: damage to surface cells and blindness
  - gamma rays: cancer, mutation (P3.15)

Light and sound

Candidates will be assessed on their ability to:

- recall that light waves are transverse waves which can be reflected, refracted and diffracted (P3.16)
- describe the role of total internal reflection in transmitting information along optical fibres and in prisms (P3.17)
- understand the difference between analogue and digital signals (P3.18)
- **describe how digital signals can carry more information (P3.19)**
- recall that sound waves are longitudinal waves which can be reflected, refracted and diffracted (P3.20)
- recall that the frequency range for human hearing is 20 Hz – 20 000 Hz (P3.21)
- understand the nature of ultrasound as high-frequency sound and its applications in scanning, cleaning and range or direction finding (P3.22)

P4: The Earth and beyond

- The Solar system
- The rest of the Universe

The Solar system

Candidates will be assessed on their ability to:

- interpret physical data on the planets, particularly with regard to their masses and their orbits in the Solar system (P4.01)
- describe the differences between the orbits of a planet and a moon, and also of a comet, and describe the different types of orbit of satellites around the Earth (P4.02)

- understand that the movements and orbits of planets and moons, and of comets and satellites, are determined by gravitational forces (P4.03)

The rest of the Universe

Candidates will be assessed on their ability to:

- recall that the Sun is one of many millions of stars in a huge group called the Milky Way galaxy (P4.04)
- describe the Universe as a system consisting of an enormous number of galaxies and be aware of the search for evidence of extraterrestrial life (P4.05)
- describe how stars form from very large clouds of hydrogen, helium and dust which collapse under the influence of gravity so that the core becomes hot enough for nuclear reactions to begin (P4.06)
- recall that small stars, like the Sun, eventually become red giants and later become white dwarfs (P4.07)
- describe the 'Big Bang' theory of the origin of the Universe and consider other theories such as the 'steady state' theory (P4.08)

- **recall evidence for the 'Big Bang' theory, including the different red shifts of light from distant galaxies and the background microwave radiation (P4.09)**

- explain how the future of the Universe depends on the amount of mass present (P4.10)

P5: Energy resources and energy transfer

- Units
- Energy transfer
- Work and power
- Energy resources and electricity generation

Units

Candidates will be assessed on their ability to:

- use the following units: degree Celsius (°C), joule (J), newton (N), watt (W), kilowatt (kW), megawatt (MW) (P5.01)

Energy transfer

Candidates will be assessed on their ability to:

- describe energy transfers involving the following forms of energy: thermal, light, electrical, sound, movement (kinetic), chemical, nuclear and potential (elastic and gravitational) (P5.02)
- understand that energy is conserved (P5.03)
- recall that efficiency is the proportion of energy transferred to useful work and apply this to everyday situations (P5.04)
- describe a variety of everyday and scientific devices and situations, explaining the fate of the input energy in the above terms, including their representation by flow diagrams (Sankey diagrams) (P5.05)
- describe how insulation is used to reduce energy transfers from buildings and the human body (P5.06)
- **understand that many insulating materials make use of the insulating properties of air that is not free to form convection currents (P5.07)**

Work and power

Candidates will be assessed on their ability to:

- recall and use the quantitative relationship between work, force and distance moved in the direction of the force:
  work done = force × distance moved $W = F \times d$ (P5.08)
- understand that work done is equal to energy transferred (P5.09)
- **recall and use the quantitative relationships:**
  gravitational potential energy = mass × g × height GPE = $m \times g \times h$
  kinetic energy = ½ × mass × speed^2 KE = ½ × $m \times v^2$ (P5.10)
- understand how conservation of energy produces a quantitative link between potential energy, kinetic energy and work (P5.11)
- describe power as the rate of transfer of energy or the rate of doing work (P5.12)

- use the quantitative relationship between power, work done (energy transferred) and time taken:

$$\text{power} = \frac{\text{work done}}{\text{time taken}} \quad P = \frac{W}{t} \qquad \text{(P5.13)}$$

Energy resources and electricity generation

Candidates will be assessed on their ability to:

- understand a range of energy transfer chains illustrating the environmental implications of generating electricity, including:
  - the use of wind and water
  - geothermal resources
  - solar heating systems and electricity production through solar cells
  - fossil fuel reserves
  - nuclear power (P5.14)
- **describe the advantages and disadvantages of methods of large scale electricity production using a variety of renewable and non-renewable resources (P5.15)**

P6: Radioactivity

- Units
- Radioactivity

Units

Candidates will be assessed on their ability to:

- use the following unit: becquerel (Bq) (P6.01)

Radioactivity

Candidates will be assessed on their ability to:

- describe the structure of an atom in terms of protons, neutrons and electrons and use symbols such as $^{14}_{6}C$ to describe particular nuclei (P6.02)
- understand the terms atomic (proton) number and mass (nucleon) number and explain the existence of isotopes (P6.03)

- understand that alpha and beta particles and gamma rays are ionising radiations emitted from unstable nuclei in a random process (P6.04)
- describe the nature of alpha and beta particles and gamma rays and recall that they may be distinguished in terms of penetrating power and ionising ability (P6.05)
- **describe the effects on the atomic and mass numbers of a nucleus of the emission of each of the three main types of radiation and understand how to complete balanced nuclear equations (P6.06)**
- understand that ionising radiation can be detected using a photographic film or a Geiger-Müller detector (P6.07)
- recall the existence of background radiation from the Earth and from space, including the regional variations in the United Kingdom, eg because of radon gas released from rocks (P6.08)
- understand that the activity of a radioactive source decreases over a period of time and is measured in becquerels (P6.09)
- recall the term half-life and understand that it is different for different radioactive isotopes (P6.10)
- use the concept of half-life to carry out simple calculations on activity (P6.11)
- describe the uses of radioactivity in medical and non-medical tracers, in radiotherapy and in the radioactive dating of archaeological specimens and rocks (P6.12)
- describe the dangers of ionising radiations including:
  - radiation can cause mutations in living organisms
  - radiation can damage cells and tissue
  - the problems arising in the disposal of radioactive waste (P6.13)

Specification content – Single Award

Specification content for the Double Award starts on page 14. The statements in the Single Award correspond with those in the Double award.

In both the Double and Single Award, some content is designated for the **higher tier candidates** only. This content is printed in **bold**.

B1: Humans as organisms

- Cell activity
- Nutrition
- Blood
- Nervous coordination
- Hormonal coordination
- Maintaining the internal environment

Cell activity

Candidates will be assessed on their ability to:

- recall that a nucleus, cytoplasm and a cell membrane are present in most animal cells (B1.01)
- recognise that the co-ordinated activity of organisms results from the action of cells adapted to different functions; relate the structure of a motor nueron (nerve cell) to its function (B1.04)

Nutrition

In order to meet statutory requirements, candidates following the Welsh National Curriculum should be taught how the presence of starch, sugar and protein in foods can be detected by testing.

Candidates will be assessed on their ability to:

- describe the functions of the mouth, oesophagus (gullet), stomach, small and large intestines, pancreas, liver and gall bladder (B1.05)
- understand the role of the muscular wall of the gut in peristalsis (B1.06)
- explain how the structure of villi (large surface area, single layer of cells and capillary network) allows efficient absorption of the soluble products of digestion (B1.07)
- understand the role of bile and of digestive enzymes: bile neutralises stomach acid and emulsifies fats; amylase digests starch to simple sugars; proteases (eg pepsin) digest proteins to amino acids; lipase digests fats to fatty acids and glycerol (B1.08)
- understand that enzymes are sensitive to temperature and pH; interpret data from experiments relating to digestion (B1.09)

Blood

Candidates will be assessed on their ability to:

- describe the composition of blood: plasma, red blood cells, white blood cells and platelets (B1.10)
- understand the roles of these components in: the transport of oxygen, nutrients, carbon dioxide, urea, hormones and thermal energy (heat); combating infection, including the ingestion of micro-organisms and the production of antibodies which destroy micro-organisms; blood clotting (to prevent blood loss and entry of micro-organisms) (B1.11)

Nervous coordination

Candidates will be assessed on their ability to:

- recall that the central nervous system (brain and spinal cord) is linked to sense organs by nerves (B1.20)
- understand that stimulation of receptors in the sense organs sends electrical impulses along nerves into and then out of the central nervous system, resulting in rapid responses; describe the differences between voluntary and reflex responses (B1.21)
- **describe the pathway taken by electrical impulses along a sensory nueron, a relay nueron and a motor nueron to an effector (muscle or gland); understand the role of transmitter chemicals at synapses; explain the removal of a finger from a hot object (B1.22)**
- describe the role of the iris and pupil, retina and optic nerve in the iris reflex (B1.23)
- **explain the role of cornea, ciliary body, suspensory ligaments and lens in forming sharp images of near and distant objects on the retina (B1.24)**

Hormonal coordination

Candidates will be assessed on their ability to:

- define hormones as chemicals released directly into the blood from glands: testosterone from the testes, oestrogen from the ovaries, progesterone from the ovaries and placenta, follicle stimulating hormone (FSH) and lutenising hormone (LH) from the pituitary gland (B1.25 in part)
- describe the roles of oestrogen and testosterone in promoting secondary sexual characteristics and the production of gametes (B1.27)
- explain:
  - the role in the menstrual cycle of FSH, oestrogen, LH and progesterone
  - the use of sex hormones in the control and promotion of fertility (B1.28)
- **describe the roles of adrenaline, released from the adrenal glands, in preparing the body for increased activity (B1.29)**

Maintaining the internal environment

Candidates will be assessed on their ability to:

- define homeostasis as the maintenance of a constant internal environment and understand why this is important (B1.30)
- explain how sweating and shivering help to maintain constant body temperature (B1.31)
- **explain the role of vasodilation and vasoconstriction in temperature regulation (B1.32)**
- recall that urea is removed by the kidneys in urine (B1.34)
- **describe the structure of a nephron to include Bowman's (renal) capsule and glomerulus, coiled tubules, collecting duct, arterioles and capillaries (B1.35)**
- **describe:**
  - **ultrafiltration in Bowman's capsule**
  - **the composition of glomerular filtrate**
  - **reabsorption in the coiled tubules (B1.36)**
- **explain the role of ADH in regulating the water content of the blood (B1.37)**
- understand the roles of skin, stomach acid and blood in defending the body against infection (B1.38)
- describe the harmful effects of:
  - solvents on the lungs and nuerons
  - alcohol on reaction times, behaviour, liver and brain
  - smoking tobacco on the occurrence of bronchitis, emphysema, lung cancer and addiction to nicotine (B1.40)

- evaluate the use and misuse of drugs including, antibiotics (eg penicillin), pain killers (eg aspirin and heroin), stimulants (eg caffeine and amphetamines), sedatives (eg barbiturates) and the dangers of contracting HIV and hepatitis by the use of intravenous drugs (B1.41)

B3: Variation, inheritance and evolution

- Variation
- Inheritance
- Evolution

Variation

Candidates will be assessed on their ability to:

- recall that the nucleus of a cell contains chromosomes on which genes (units of inherited information) are located (B3.01)
- understand that:
  - variation between individuals arises from genetic and environmental causes and from a combination of both
  - environmental conditions during growth and development cause variation between genetically identical individuals (B3.04)
- understand:
  - that genes exist in alternative forms (alleles) which cause variation in inherited characteristics
  - the terms dominant and recessive
  - some alleles cause diseases which can be inherited (B3.05)
- recall that:
  - chromosomes are present as pairs in body cells and singly in gametes
  - 46 and 23 are the diploid and haploid numbers of chromosomes in human cells (B3.06)
- **understand that division of a cell by mitosis produces two cells which contain identical sets of chromosomes for growth and replacement; interpret diagrams showing the overall behaviour of chromosomes during mitosis (technical terms not required) (B3.07)**
- **understand that division of a cell by meiosis produces four cells, each with half the number of chromosomes for the formation of genetically different haploid gametes during sexual reproduction; interpret simple diagrams and photographs showing stages in meiosis (technical terms not required) (B3.08)**
- define fertilisation as the fusion of haploid male and female gametes, restoring the diploid number of chromosomes in the zygote; explain the resulting genetic variation in the new generation of individuals (B3.09)
- explain that asexual reproduction involves only one parent and gives rise to genetically identical offspring (clones) (B3.10)
- recall that a mutation is a change in a gene, DNA or the number of chromosomes in a cell which leads to genetic variation (B3.11)

- understand that many mutations are harmful, some are neutral and a few are beneficial and can increase in the population by natural selection (B3.12)
- understand that exposure to ionising radiation (including gamma rays, ultraviolet rays and X-rays) and some chemical mutagens (including chemicals in tobacco) increase the incidence of mutations (B3.13)

Inheritance

Candidates will be assessed on their ability to:

- recall that the sex of a person is controlled by one pair of chromosomes, XX in a female or XY in a male; describe the determination of the sex of offspring at fertilisation, using a genetic diagram (B3.14)
- describe the mechanism of monohybrid inheritance using a crossing diagram (B3.15)
- **understand how individuals can be homozygous or heterozygous for particular alleles; distinguish between genotype and phenotype (B3.16)**
- **predict probabilities of inheritance from parents using genetic diagrams (B3.17)**
- **explain family trees showing the inheritance of polydactyly (dominant allele) and cystic fibrosis (recessive allele) (B3.18)**

- describe some of the implications of the outcome of the Human Genome Project (B3.19)
- describe how selective breeding is used to develop crop plants and agricultural animals with desirable characteristics such as resistance to disease and production of high yields (B3.20)
- understand that cloning is used to produce large numbers of identical individuals with desirable characteristics eg plant cuttings (B3.21)

- describe the ethical implications of selective breeding and cloning (B3.22)

- **describe how the transfer of a required gene from a donor to a recipient, including the use of restriction enzymes and ligase, can produce genetically modified organisms (B3.23)**
- **evaluate the ethical implications of genetic modification (B3.24)**

Evolution

Candidates will be assessed on their ability to:

- understand that fossils provide evidence of evolution (B3.25)
- describe how inherited variation can lead to evolution or extinction by the process of natural selection (B3.26)

B4: Living organisms in their environment

- Humans and the environment

Humans and the environment

Candidates will be assessed on their ability to:

- understand the principles of interdependence, adaptation, competition and predation; explain how these factors influence the distribution and population sizes of organisms in a given terrestrial or aquatic environment (B4.01)
- describe the impact of human activity on the environment, including the pollution of air and of water; recall the effects of air pollutants (eg sulfur dioxide, carbon monoxide) and of water pollutants (eg sewage, nitrates and phosphates) (B4.02)
- relate the level of impact on the environment to population size, economic factors and industrial requirements (B4.03)
- describe the effects of deforestation and overfishing; understand the importance of protecting natural population (B4.04)

C1: Classifying materials

- Atomic structure
- Bonding

Atomic structure

Candidates will be assessed on their ability to:

- describe the structure of an atom as a nucleus containing protons and neutrons, surrounded by orbiting electrons arranged in shells (C1.01)
- recall the relative mass and relative charge of a proton, a neutron and an electron (C1.02)
- understand the terms atomic number, mass number and relative atomic mass (C1.03)
- describe the electronic structures of the first twenty elements in the periodic table in terms of number of electrons in electron shells, given the atomic numbers (C1.04)

Bonding

Candidates will be assessed on their ability to:

- understand that atoms of different elements can combine to form compounds by the formation of new chemical bonds (C1.07)
- understand that ionic bonds can be made by the transfer of electrons to form cations and anions (C1.08)
- understand that covalent bonds can be made by electron sharing to form molecules (C1.11)
- describe the formation, including dot and cross diagrams, of simple molecules including H_2, HC1, H_2O **and CO_2** (C1.12)

C2: Changing materials – formulae and equations

- Representing reactions

Representing reactions

Candidates will be assessed on their ability to:

- represent chemical reactions by word equations (C2.01)
- recall the formulae of elements and simple compounds in the specification (C2.02)
- write simple balanced equations (C2.04)
- use the state symbols (s), (l), (g) and (aq) (C2.05)

C3: Patterns of behaviour – in elements and compounds

- The periodic table
- Noble gases
- Alkali metals
- Halogens
- Chemicals from calcium carbonate

The periodic table

Candidates will be assessed on their ability to:

- recall that there are approximately 100 elements and that all materials are composed of one or more of these (C3.01)
- understand that the periodic table shows elements in order of increasing atomic number, arranged in rows (periods) (C3.02)
- recall that elements with similar properties appear in the same vertical column (group) (C3.03)
- recall the positions of the alkali metals (group 1), the halogens (group 7) and the noble gases (group 0) in the periodic table (C3.04 in part)
- understand the connection between the number of outer electrons and the position of an element in the periodic table (C3.05)
- understand that the reactions of elements depend upon the arrangement of electrons in their atoms (C3.06)
- recall that there is a gradual change in the properties of the elements from the top to the bottom of each group (C3.07)

Alkali metals

Candidates will be assessed on their ability to:

- recall that the alkali metals have comparatively low melting points and boiling points and are softer than other metals (C3.10)
- describe the relative reactivity of the alkali metals as exemplified by their reaction with water (C3.11)
- recall that common compounds of the alkali metals are soluble in water and that the oxides and hydroxides of the alkali metals are alkaline (pH>7) (C3.12)

Halogens

Candidates will be assessed on their ability to:

- recall the colours and physical states of the halogens at room temperature (C3.13)
- recall that halogens react with metals to form metal halides (C3.14)
- recall that halogens react with hydrogen to produce hydrogen halides which dissolve in water to form acidic solutions (pH<7) (C3.15)

- describe the relative reactivity of the halogens as exemplified by their displacement reactions with halide ions in aqueous solution (C3.16)
- describe the use of fluorides in the water supply and in toothpaste, of chlorine in water purification and of iodine as an antiseptic (C3.17)

Chemicals from calcium carbonate

Candidates will be assessed on their ability to:

- describe the thermal decomposition of calcium carbonate to make calcium oxide and carbon dioxide (C3.23)

C4: Changing materials – useful products

- Useful products from crude oil

Useful products from crude oil

Candidates will be assessed on their ability to:

- recall that hydrocarbons contain carbon and hydrogen only and that crude oil is a mixture of hydrocarbons (C4.11)
- describe the fractional distillation of crude oil (C4.12)
- understand that the larger the hydrocarbon molecule, the higher the boiling point of the hydrocarbon and the less volatile it is at a given temperature (C4.13)
- recall the uses of the main fractions (gases, petrol, naphtha, kerosene, diesel oil, fuel oil, bitumen) (C4.14)

- recall and explain the formation of the products of the complete and incomplete combustion (oxidation) of hydrocarbons, and the possible effect of these on the environment (C4.15)
- describe how to test for carbon dioxide (using lime water) and water (using cobalt chloride) (C4.16)
- **explain that cracking involves the breaking down of larger hydrocarbon molecules into smaller, more useful ones, some of which have carbon-carbon double bonds (C4.17)**
- **explain that alkanes are saturated hydrocarbons and that alkenes are unsaturated hydrocarbons (C4.20)**
- recall that methane is the main constituent of natural gas (C4.21)
- recall the formulae of methane, ethane, propane and butane (not methyl propane) and draw the structures of these molecules (C4.22)
- **recall the formulae of ethene and propene and draw the structures of their molecules (C4.23)**
- **describe how bromine water is used to distinguish between alkanes and alkenes (C4.24)**
- recall that polymers are large molecules which can be formed by a combination of many smaller molecules (C4.25)
- **explain how addition polymers are formed from unsaturated monomers (equations required but not conditions and mechanisms) (C4.26)**

- describe the uses and associated properties of poly(ethene), poly(propene) and poly(chloroethene) (C4.27)

C5: Patterns of behaviour – in reactions

- Rates of reaction

Rates of reaction

Candidates will be assessed on their ability to:

- recall that the rates of chemical reactions vary from very fast, explosive reactions to very slow reactions which form no detectable products (C5.01)
- describe experiments to investigate the effect of temperature, concentration and surface area of a solid on the rate of a reaction (C5.02)
- interpret the results of such experiments (C5.03)
- recall and explain the effect of changes in temperature, concentration and surface area of a solid on a given rate of reaction (C5.04)
- understand that reactions can occur when particles collide and that increasing the frequency and energy of collisions increases the rate of the reaction (C5.05)

- describe the effect of a catalyst on a given rate of reaction (C5.06)
- define enzymes as catalysts in biological systems and describe their use in washing powder, and food and drink manufacture (C5.07)

P1: Electricity and magnetism

- Units
- Mains electricity
- Energy and potential difference in circuits
- Electromagnetic induction

Units

Candidates will be assessed on their ability to:

- use the following units: ampere (A), ohm (Ω), volt (V), watt (W), kilowatt-hour (kW h) (P1.01)

Mains electricity

Candidates will be assessed on their ability to:

- identify the live, neutral and earth conductor in a correctly-wired plug and recall the colour of the insulation used on each conductor (P1.02)
- recall the hazards of electricity including frayed cables, long cables, damaged plugs, water around sockets and pushing metal objects into sockets (P1.03)
- describe the uses of insulation, double insulation, earthing, fuses and circuit breakers in a range of domestic appliances (P1.04)
- recall that electrical heating is used in a variety of ways in domestic contexts (P1.05)
- understand that a current in a resistor results in the electrical transfer of energy and an increase in temperature (P1.06)
- calculate the energy used by domestic appliances in kilowatt-hours and calculate domestic electricity bills, based on meter readings (P1.08)
- **use the quantitative relationship between energy transferred, current, voltage and time:**
  energy transferred = current × voltage × time $E = I \times V \times t$ **(P1.09)**
- recall that mains electricity is alternating current (a.c.) and understand the difference between this and the direct current (d.c.) supplied by a cell (P1.10)

Energy and potential difference in circuits

Candidates will be assessed on their ability to:

- explain whether a series or parallel circuit is more appropriate for a range of applications, including domestic lighting (P1.11)
- understand that the current in a series circuit depends on the applied voltage and the number and nature of other components (P1.12)
- describe how current varies with voltage in wires, resistors, metal filament lamps and diodes and how this can be investigated experimentally (P1.13)
- describe the qualitative effect of changing resistance on the current in a circuit (P1.14)
- describe the qualitative variation of resistance of LDRs with illumination and of thermistors with temperature (P1.15)

- recall and use the quantitative relationship between voltage, current and resistance: voltage = current × resistance $V = I \times R$ (P1.16)

Electromagnetic induction

Candidates will be assessed on their ability to:

- describe the generation of electricity by the rotation of a magnet within a coil of wire and of a coil of wire within a magnetic field and the factors which affect the size of the induced voltage (P1.31)
- describe the use of step-up and step-down transformers in the large-scale transmission of electrical energy (P1.33)
- **recall and use the quantitative relationship between input (primary) and output (secondary) voltages and the turns ratio for a transformer:**

$$\frac{\mathbf{voltage(primary)}}{\mathbf{voltage(secondary)}} = \frac{\mathbf{turns(primary)}}{\mathbf{turns(secondary)}}$$

$$\frac{V_P}{V_S} = \frac{n_P}{n_S}$$ **(P1.34)**

P3: Waves

- Units
- Properties of waves
- The electromagnetic spectrum
- Light and sound

Units

Candidates will be assessed on their ability to:

- use the following units: hertz (Hz), kilohertz (kHz), megahertz (MHz), metre/second (m/s) (P3.01)

Properties of waves

Candidates will be assessed on their ability to:

- describe longitudinal and transverse waves in ropes, springs and water (P3.02)
- state the meaning of amplitude, frequency, wavelength and period of a wave (P3.03)
- recall that waves transfer energy and information without transferring matter (P3.04)
- understand that waves can be diffracted through gaps and that the extent of diffraction depends on the wavelength and the size of the gap (P3.08)

The electromagnetic spectrum

Candidates will be assessed on their ability to:

- understand that light is part of a continuous electromagnetic spectrum which includes radio, microwave, infra-red, visible, ultraviolet, X-ray and gamma ray radiations and that all these waves travel at the same speed in free space (P3.12)
- recall the order of the electromagnetic spectrum in decreasing wavelength and increasing frequency, including the colours of the visible spectrum (P3.13)
- recall some uses of electromagnetic radiations including:
  - radio waves: broadcasting and communications
  - microwaves: cooking and satellite transmissions
  - infra-red: heaters, grills, night vision and remote controls
  - visible light: optical fibres and photography
  - ultraviolet: sunbeds, crime prevention and fluorescent lamps
  - X-rays: observing the internal structure of objects and materials, medical applications
  - gamma rays: sterilising food and medical equipment (P3.14)
- recall the detrimental effects of excessive exposure of the human body to electromagnetic waves of increasing frequencies including:
  - microwaves: internal heating of body tissue
  - infra-red: skin burns

- ultraviolet: damage to surface cells and blindness
- gamma rays: cancer, mutation (P3.15)

Light and sound

Candidates will be assessed on their ability to:

- recall that light waves are transverse waves which can be reflected, refracted and diffracted (P3.16)
- describe the role of total internal reflection in transmitting information along optical fibres and in prisms (P3.17)
- understand the difference between analogue and digital signals (P3.18)
- **describe how digital signals can carry more information (P3.19)**
- recall that sound waves are longitudinal waves which can be reflected, refracted and diffracted (P3.20)
- recall that the frequency range for human hearing is 20 Hz – 20 000 Hz (P3.21)
- understand the nature of ultrasound as high-frequency sound and its applications in scanning, cleaning and range or direction finding (P3.22)

P4: The Earth and beyond

- The Solar system
- The rest of the Universe

The Solar system

Candidates will be assessed on their ability to:

- interpret physical data on the planets, particularly with regard to their masses and their orbits in the Solar system (P4.01)
- describe the differences between the orbits of a planet and a moon, and also of a comet, and describe the different types of orbit of satellites around the Earth (P4.02)

- understand that the movements and orbits of planets and moons, and of comets and satellites, are determined by gravitational forces (P4.03)

The rest of the Universe

Candidates will be assessed on their ability to:

- recall that the Sun is one of many millions of stars in a huge group called the Milky Way galaxy (P4.04)
- describe the Universe as a system consisting of an enormous number of galaxies and be aware of the search for evidence of extraterrestrial life (P4.05)
- describe how stars form from very large clouds of hydrogen, helium and dust which collapse under the influence of gravity so that the core becomes hot enough for nuclear reactions to begin (P4.06)
- recall that small stars, like the Sun, eventually become red giants and later become white dwarfs (P4.07)
- describe the 'Big Bang' theory of the origin of the Universe and consider other theories such as the 'steady state' theory (P4.08)

- **recall evidence for the 'Big Bang' theory, including the different red shifts of light from distant galaxies and the background microwave radiation (P4.09)**

- explain how the future of the Universe depends on the amount of mass present (P4.10)

P5: Energy resources and energy transfer

- Units
- Energy transfer
- Energy resources and electricity generation

Units

Candidates will be assessed on their ability to:

- use the following units: degree Celsius (^{o}C), joule (J), newton (N), watt (W), kilowatt (kW), megawatt (MW) (P5.01)

Energy transfer

Candidates will be assessed on their ability to:

- describe energy transfers involving the following forms of energy: thermal, light, electrical, sound, movement (kinetic), chemical, nuclear and potential (elastic and gravitational) (P5.02)
- understand that energy is conserved (P5.03)
- recall that efficiency is the proportion of energy transferred to useful work and apply this to everyday situations (P5.04)
- describe a variety of everyday and scientific devices and situations explaining the fate of the input energy in the above terms, including their representation by flow diagrams (Sankey diagrams) (P5.05)
- describe how insulation is used to reduce energy transfers from buildings and the human body (P5.06)
- **understand that many insulating materials make use of the insulating properties of air that is not free to form convection currents (P5.07)**

Energy resources and electricity generation

Candidates will be assessed on their ability to:

- understand a range of energy transfer chains illustrating the environmental implications of generating electricity, including:
  - the use of wind and water
  - geothermal resources
  - solar heating systems and electricity production through solar cells
  - fossil fuel reserves
  - nuclear power (P5.14)
- **describe the advantages and disadvantages of methods of large scale electricity production using a variety of renewable and non-renewable resources (P5.15)**

P6: Radioactivity

- Units
- Radioactivity

Units

Candidates will be assessed on their ability to:

- use the following unit: becquerel (Bq) (P6.01)

Radioactivity

Candidates will be assessed on their ability to:

- describe the structure of an atom in terms of protons, neutrons and electrons and use symbols such as $^{14}_{6}C$ to describe particular nuclei (P6.02)
- understand the terms atomic (proton) number and mass (nucleon) number and explain the existence of isotopes (P6.03)

- understand that alpha and beta particles and gamma rays are ionising radiations emitted from unstable nuclei in a random process (P6.04)
- describe the nature of alpha and beta particles and gamma rays and recall that they may be distinguished in terms of penetrating power and ionising ability (P6.05)
- **describe the effects on the atomic and mass numbers of a nucleus of the emission of each of the three main types of radiation and understand how to complete balanced nuclear equations (P6.06)**
- understand that ionising radiation can be detected using a photographic film or a Geiger-Müller detector (P6.07)
- recall the existence of background radiation from the Earth and from space, including the regional variations in the United Kingdom, eg because of radon gas released from rocks (P6.08)
- understand that the activity of a radioactive source decreases over a period of time and is measured in becquerels (P6.09)
- describe the uses of radioactivity in medical and non-medical tracers, in radiotherapy and in the radioactive dating of archaeological specimens and rocks (P6.12)
- describe the dangers of ionising radiations including:
  - radiation can cause mutations in living organisms
  - radiation can damage cells and tissue
  - the problems arising in the disposal of radioactive waste (P6.13)

Internal assessment

Sc1 Scientific Enquiry: Investigative Skills Assessment

Introduction

As set out on page 5, candidates are required to produce evidence in the four skill areas for Sc1, Scientific Enquiry, in the context of experimental and investigative skills. The following section offers guidance to teachers on the implementation of the assessment scheme, as agreed by the awarding bodies.

The evidence for assessment in this attainment target (Sc1) will be coursework carried out by the candidate, set in the contexts of the other three attainment targets (Sc2, Sc3, Sc4). The assessment scheme caters for a wide range of experimental and investigative work. Candidates should undertake experimental and investigative work during the course and be assessed on several occasions in both types of activity. The aim is to allow them to achieve their highest potential in such work. Candidates are required to produce the evidence for assessment based on the guidelines on page 5.

- The term 'evidence' is used throughout the assessment scheme to mean data, observations or measurements.
- An activity can take the form of experimental work or an investigation. Experimental work may be used to assess one, two or three skill areas.
- An investigation consists of work that covers each of the four skill areas, although not all of these need to be used for assessment.
- In the mark descriptions for the assessment of Sc1, the use of terms such as 'plan', 'communicate', 'record', 'identify', 'explain', 'comment', 'consider', and 'describe' ensures that the quality of written communication will form part of the assessment.

The scheme of internal assessment is designed to encourage a wide variety of activities. These include those based on the collection of first-hand evidence and those which depend on secondary evidence. The term 'evidence' has been used consistently throughout the assessment scheme to mean observations, measurements or other data. Through the teaching of investigative skills, candidates should be given opportunities to apply and develop their ICT capability. In particular, candidates could:

- use data-handling software to analyse data from fieldwork
- use data-handling software to create, analyse and evaluate charts and graphs
- use data loggers in investigations
- use spreadsheets for data analysis
- use the Internet or CD ROM software as sources of secondary evidence.

Assessment

Four skill areas are used to assess activities, as appropriate.

Candidates will be expected to:

	Mark scale
Plan experimental procedures (P)	0 – 8
Obtain evidence (O)	0 – 8
Analyse this evidence and draw conclusions (A)	0 – 8
Evaluate evidence (E)	0 – 6

Mark descriptions are defined at steps 0, 2, 4, 6 and 8 as appropriate. They are closely aligned with the Key Stage 3 'level descriptions' and should ensure smooth progression and continuity of good practice from Key Stage 3 to Key Stage 4.

Mark descriptions comprising a number of statements are provided in each skill area. Activities chosen for assessment should, wherever possible, provide opportunities for all the statements in a mark description to be addressed. It should be noted that some of the statements in a mark description contain a phrase such as 'where appropriate' and therefore may not apply to a particular activity.

Descriptions are provided for 2, 4, 6 and 8 marks in skill areas P, O and A and 2, 4 and 6 marks in skill area E. The performance needed to gain 6 marks in skill area E is commensurate with that for 8 marks in the other skill areas.

Whenever assessments are made, the mark descriptions should be used to judge which mark best fits the candidate's performance. The statements should not be taken as discrete and literal hurdles, all of which must be fulfilled for a mark to be awarded.

The mark descriptions within a skill area are designed to be hierarchical. This means that, in general, a description at a particular mark subsumes those at lower marks. It is assumed that activities that access higher marks will involve a more sophisticated approach and/or a more complex treatment. Adjacent descriptions should be considered when making judgements and use made of the intermediate marks (ie 3, 5 and 7) where performance exceeds one description and only partially satisfies the next.

A candidate who fails to meet the requirements for 2 marks but who has made a creditworthy attempt in a skill area should be given 1 mark for that skill. Zero marks should only be awarded for a skill area in the unlikely event of a candidate failing to demonstrate any achievement in that skill.

The professional judgement of the teacher in making these assessments is important.

The scheme is supported by materials with suggested experiments and investigations, plus exemplar assessed work.

Safe practice

Attention is drawn to the need for safe practice when candidates carry out laboratory investigations or observe demonstrations. Particular attention is drawn to the possible hazards associated with electrical equipment, the handling of micro-organisms, and ionising radiations. Strict aseptic conditions should be used when undertaking practical work. Reference must be made to COSHH regulations and any specific Local Education Authority restrictions.

Relevant advice can be obtained from the following publications:

COSHH; Guidance for Schools (HSC 1989); HMSO; ISBN 011 885 5115

Topics in Safety – 3rd Ed – Association for Science Education (ASE), January 2001
ISBN 086 357 3169

CLEAPSS Laboratory Handbook and Hazards (available from Consortium of Local Education Authority for the Provision of Science Services (CLEAPSS) to members or associates only)

Skill Area P: Planning

Programme of study requirements
Candidates should be taught to: **a** use scientific knowledge and understanding to turn ideas into a form that can be investigated, and to plan an appropriate strategy **b** decide whether to use evidence from first-hand experience or secondary sources **c** carry out preliminary work and make predictions, where appropriate **d** consider key factors that need to be taken into account when collecting evidence, and how evidence can be collected in contexts in which the variables cannot readily be controlled **e** decide the extent and range of data to be collected, and the techniques, equipment and materials to use.

Mark descriptions

The mark descriptions are designed to be hierarchical.

All work should be assessed in the context of the specification content.

	Candidates:		Increasing demand of activity
2 marks	P.2a	outline a simple procedure	↓
4 marks	P.4a	plan to collect evidence which will be valid	
	P.4b	plan the use of suitable equipment or sources of evidence	
6 marks	P.6a	use scientific knowledge and understanding to plan and communicate a procedure, to identify key factors to vary, control or take into account, and to make a prediction where appropriate	
	P.6b	decide a suitable extent and range of evidence to be collected	
8 marks	P.8a	use detailed scientific knowledge and understanding to plan and communicate an appropriate strategy, taking into account the need to produce precise and reliable evidence, and to justify a prediction, when one has been made	
	P.8b	use relevant information from preliminary work, where appropriate, to inform the plan	

Skill Area O: Obtaining evidence

Programme of study requirements
Candidates should be taught to: **f** use a wide range of equipment and materials appropriately, and manage their working environment to ensure the safety of themselves and others **g** make observations and measurements, including the use of ICT for datalogging to a degree of precision appropriate to the context **h** make sufficient observations and measurements to reduce error and obtain reliable evidence **i** judge the level of uncertainty in observations and measurements **j** represent and communicate qualitative and quantitative data using diagrams, tables, charts, graphs and ICT.

Mark descriptions

The mark descriptions are designed to be hierarchical.

All work should be assessed in the context of the specification content.

	Candidates:		Increasing demand of activity
2 marks	O.2a	collect some evidence using a simple and safe procedure	
4 marks	O.4a O.4b	collect appropriate evidence which is adequate for the activity record the evidence	
6 marks	O.6a O.6b	collect sufficient systematic and accurate evidence and repeat or check where appropriate record clearly and accurately the evidence collected	
8 marks	O.8a	use a procedure with precision and skill to obtain and record an appropriate range of reliable evidence	

Skill Area A: Analysing and considering evidence

Programme of study requirements
Candidates should be taught to: **k** use diagrams, tables, charts and graphs, and identify and explain patterns or relationships in data **l** present the results of calculations to an appropriate degree of accuracy **m** use observations, measurements or other data to draw conclusions **n** explain to what extent these conclusions support any predictions made, and enable further predictions to be made **o** use scientific knowledge and understanding to explain and interpret observations, measurements or other data, and conclusions.

Mark descriptions			
The mark descriptions are designed to be hierarchical. All work should be assessed in the context of the specification content.			
		Candidates:	Increasing demand of activity
2 marks	A.2a	state simply what is shown by the evidence	
4 marks	A.4a	use simple diagrams, charts or graphs as a basis for explaining the evidence	
	A.4b	identify trends and patterns in the evidence	
6 marks	A.6a	construct and use suitable diagrams, charts, graphs (with lines of best fit, where appropriate), or use numerical methods, to process evidence for a conclusion	
	A.6b	draw a conclusion consistent with the evidence and explain it using scientific knowledge and understanding	
8 marks	A.8a	use detailed scientific knowledge and understanding to explain a valid conclusion drawn from processed evidence	
	A.8b	explain the extent to which the conclusion supports the prediction, if one has been made	

Skill Area E: Evaluating

Programme of study requirements
Candidates should be taught to: **p** consider anomalous data, giving reasons for rejecting or accepting them, and consider the reliability of data in terms of uncertainty of measurements and observations **q** consider whether the evidence collected is sufficient to support any conclusions or interpretations made **r** suggest improvements to the methods used **s** suggest further investigations.

Mark descriptions			
The mark descriptions are designed to be hierarchical. All work should be assessed in the context of the specification content.			
		Candidates:	Increasing demand of activity
2 marks	E.2a	make a relevant comment about the procedure used or the evidence obtained	
4 marks	E.4a	comment on the quality of the evidence, identifying any anomalies	
	E.4b	comment on the suitability of the procedure and, where appropriate, suggest changes to improve it	
6 marks	E.6a	consider critically the reliability of the evidence and whether it is sufficient to support the conclusion, accounting for any anomalies	
	E.6b	describe, in detail, further work to provide additional relevant evidence	

Grade descriptions

The following grade descriptions indicate the level of attainment characteristic of the given grade at GCSE. They give a general indication of the required learning outcomes at each specified grade. The descriptions should be interpreted in relation to the content outlined in the specification; they are not designed to define that content. The grade awarded will depend in practice upon the extent to which the candidate has met the assessment objectives overall. Shortcomings in some aspects of the examination may be balanced by better performances in others.

Grade F

Candidates recall a limited range of information. For example, they state the main functions of organs of the human body, describe some defence mechanisms of the body, state some uses of materials obtained from oil, suggest ways in which insulation is used in domestic contexts.

Candidates use and apply knowledge and understanding in some specific everyday contexts. For example, they describe how a reduction in the population of one organism in a habitat can affect another organism, suggest a way of speeding up a particular chemical reaction; explain that fuels are energy resources and that energy is sometimes 'wasted'. Candidates make some use of scientific and technical vocabulary and make simple generalisations from information.

Candidates relate scientific explanations to some experimental evidence and describe simple examples of benefits and drawbacks of scientific development.

Candidates devise fair tests in contexts which involve only a few factors. They use simple apparatus to make measurements appropriate to the task and record observations and measurements in tables and graphs. Candidates obtain information from simple tables, charts and graphs and identify simple patterns in information and observations. They offer explanations consistent with the evidence obtained.

Grade C

Candidates recall a range of scientific information from all areas of the specification. For example, they explain how the lungs are ventilated, recall simple chemical symbols and formulae, recall correct units for quantities.

Candidates use and apply scientific knowledge and understanding in some general contexts. For example, they describe how a cell is adapted to its functions, use simple balanced equations, use quantitative relationships between physical quantities to perform calculations. Candidates describe links between related phenomena in different contexts, use diagrams, charts and graphs to support arguments, use appropriate scientific and technical vocabulary in a range of contexts.

Candidates describe how evidence is used to test predictions made from scientific theories, and how different people may have different views on some aspects of science.

Candidates use scientific knowledge and understanding to identify an approach to a question: for example, identifying key factors to vary and control. Candidates use a range of apparatus to make careful and precise measurements and systematic observations and recognise when it is necessary to repeat measurements and observations. They present data systematically, in graphs where appropriate, and use lines of best fit. Candidates identify and explain patterns within data and draw conclusions consistent with the evidence. They explain these conclusions using scientific knowledge and understanding and evaluate how strongly their evidence supports the conclusions.

Grade A

Candidates recall a wide range of knowledge from all areas of the specification.

Candidates use detailed scientific knowledge and understanding in a range of applications relating to scientific systems or phenomena. For example, they explain how temperature or water content is regulated in humans, routinely use a range of balanced chemical equations, use the particle model to explain variations in reaction rates, use a wide range of relationships between physical quantities to carry out calculations effectively. Candidates draw together and communicate knowledge from more than one area, use routinely scientific or mathematical conventions in support of arguments, use a wide range of scientific and technical vocabulary throughout their work.

Candidates explain how scientific theories can be changed by new evidence and identify some areas of uncertainty in science.

Candidates use scientific knowledge and understanding to select an appropriate strategy for a task, identifying the key factors to be considered. They make systematic observations in qualitative work and decide which observations are relevant to the task in hand. When making measurements they decide the level of precision needed and use a range of apparatus with precision and skill to make appropriately precise measurements. They select a method of presenting data appropriate to the task; they use information from a range of sources where it is appropriate to do so. They identify and explain anomalous observations and measurements and the salient features of graphs.

Candidates use scientific knowledge and understanding to identify and explain patterns and draw conclusions from the evidence by combining data of more than one kind or from more than one source. They identify shortcomings in the evidence, use scientific knowledge and understanding to draw conclusions from their evidence and suggest improvements to the methods used that would enable them to collect more reliable evidence.

The wider curriculum

Key skills

This specification will provide opportunities, as appropriate, to develop the key skills of communication, Information Technology, application of number, improving own learning and performance, working with others and problem solving.

Examples of such opportunities are signposted in *Appendix 1*, page 92. It is important that these opportunities fall naturally into a programme of study, and it may be that not all the examples are appropriate for all programmes. The examples offered may be adapted to suit particular situations, and it will be possible to devise many alternative opportunities and approaches. The development of key skills can enhance teaching and learning strategies and can be a stimulus to new approaches, and increase levels of student involvement.

Key skills opportunities are detailed more fully in *Appendix 1*, page 92.

Mathematical skills

Candidates need to have been taught and to have acquired competence in the areas of mathematics set out below in order to develop knowledge, understanding and skills in the subject content.

Candidates are permitted to use calculators in all written papers in accordance with the current regulations.

For the purpose of this course it will be assumed that candidates will be able to:

- evaluate expressions incorporating the four operations, +, -, ×, ÷, either singly or in conjunction with one another, quoting the answer to an appropriate number of significant figures
- evaluate expressions involving simple proportion, decimals, fractions and percentages
- understand and use compound measures such as speed
- manipulate formulae, equations and expressions
- plot and draw graphs from suitable data, selecting appropriate scales for the axes
- interpret graphs in terms of general trends and by interpolation
- interpret a range of graphs and diagrams
- use an electronic calculator in connection with any of the above as appropriate
- understand that a measurement given to a whole number may be inaccurate by up to one-half in either direction.

In addition, higher tier candidates will be expected to be able to:

- **understand and use direct and inverse proportion**
- **use numbers in standard form.**

Spiritual, moral, ethical, social and cultural issues

The teaching of this specification provides many opportunities for candidates to explore these wider curriculum issues. The content of the specification raises issues of the complexities and diversity of life forms and the impact of developments of science and technology on inheritance. The physical theories the creation and nature of the universe offer candidates the opportunity to consider intricate topics based on their understanding of science.

Opportunities for the development of these issues may be found in the following sections:

- explain that asexual reproduction involves only one parent and gives rise to genetically identical offspring (clones) (B3.10)
- describe some of the implications of the outcome of the Human Genome Project (B3.19)
- understand that cloning is used to produce large numbers of identical individuals with desirable characteristics (eg plant cuttings) (B3.21)
- describe the ethical implications of selective breeding and cloning (B3.22)
- evaluate the ethical implications of genetic modification (B3.24)
- understand that the Earth's early atmosphere was probably formed from the gases produced by volcanic activity (C6.09)
- explain that the first primitive plants released oxygen as a result of photosynthesis and that the percentage of oxygen in the atmosphere gradually increased (C6.12)
- understand that the presence of fossils in a rock is evidence that it has been formed from sediments (C6.16)
- recall a brief history of our understanding of forces including:
  - the Greek view – a single force needed to sustain motion
  - Galileo and Newton – balanced forces allow an object to continue in uniform motion in a straight line or to remain at rest
  - Newton – gravitational attraction acts between all masses (P2.07)
- describe the 'Big Bang' theory of the origin of the Universe and consider other theories such as the 'steady state' theory (P4.08).

Education for citizenship

This specification identifies opportunities for candidates to develop knowledge and understanding with a view to becoming an informed citizen. This could be in the context of:

- the role of the media in providing scientific information
- wider environmental issues, including sustainable development and Local Agenda 21

Opportunities for the development of these issues may be found in the following sections:

- describe some of the implications of the outcome of the Human Genome Project (B3.19)
- evaluate the ethical implications of genetic modification (B3.24)
- describe the impact of human activity on the environment, including the pollution of air and of water; recall the effects of air pollutants (eg sulfur dioxide, carbon monoxide) and of water pollutants (eg sewage, nitrates and phosphates) (B4.02)
- describe the effects of deforestation and overfishing; understand the importance of protecting natural population (B4.04)

- recall and explain the formation of the products of the complete and incomplete combustion (oxidation) of hydrocarbons, and the possible effect of these on the environment (C4.15)
- define enzymes as catalysts in biological systems and describe their use in washing powder, and food and drink manufacture (C5.07)
- describe the potential dangers and uses of electrostatic charges generated in everyday situations, eg fuelling aircraft and tankers, photocopiers and inkjet printers (P1.27)
- recall some uses of electromagnetic radiations including:
  - radio waves: broadcasting and communications
  - microwaves: cooking and satellite transmissions
  - infra-red: heaters, grills, night vision and remote controls
  - visible light: optical fibres and photography
  - ultraviolet: sunbeds, crime prevention and fluorescent lamps
  - X-rays: observing the internal structure of objects and materials, medical applications
  - gamma rays: sterilising food and medical equipment (P3.14).
- recall the detrimental effects of excessive exposure of the human body to electromagnetic waves of increasing frequencies including:
  - microwaves: internal heating of body tissue
  - infra-red: skin burns
  - ultraviolet: damage to surface cells and blindness
  - gamma rays: cancer, mutation (P3.15).
- recall the existence of background radiation from the Earth and from space, including the regional variations in the United Kingdom, eg because of radon gas released from rocks (P6.08).

The development of the Scientific Enquiry component, ideas and evidence in science, throughout this specification supports the student in making informed decisions about eg:

- the use and abuse of statistics in health issues
- bias in scientific articles.

Information and communication technology

Students should be given opportunities to apply and develop their ICT capability through the use of ICT tools to support their learning in science.

Examples may include the use of the following ICT applications:

word-processing	understand the roles of plasma, red blood cells, white blood cells and platelets in: the transport of oxygen, nutrients, carbon dioxide, urea, hormones and thermal energy (heat); combating infection, including the ingestion of micro-organisms and the production of antibodies which destroy micro-organisms; blood clotting (to prevent blood loss and entry of micro-organisms) (B1.11)
Data logging	recall that the central nervous system (brain and spinal cord) is linked to sense organs by nerves (B1.20)
simulation	describe the role of the iris and pupil, retina and optic nerve in the iris reflex (B1.23)
Internet	describe the roles of oestrogen and testosterone in promoting secondary sexual characteristics and the production of gametes (B1.27)

datalogging	explain how sweating and shivering help to maintain constant body temperature (B1.31)
spreadsheet	explain how sweating and shivering help to maintain constant body temperature (B1.31)
word-processing	evaluate the use and misuse of drugs including antibiotics (eg penicillin), pain killers (eg aspirin and heroin), stimulants (eg caffeine and amphetamines), sedatives (eg barbiturates) and the dangers of contracting HIV and hepatitis by the use of intravenous drugs (B1.41)
Internet	evaluate the use and misuse of drugs including antibiotics eg penicillin, pain killers eg aspirin and heroin, stimulants eg caffeine and amphetamines, sedatives eg barbiturates and the dangers of contracting HIV and hepatitis by the use of intravenous drugs (B1.41)
word-processing	explain the pattern of gas exchange between a plant and the atmosphere resulting from photosynthesis and respiration over a 24 hour period (B2.05)
datalogging	describe how the rate of photosynthesis varies with carbon dioxide concentration, light intensity and temperature; interpret data from experiments relating to photosynthesis (B2.06)
datalogging	explain how leaves lose water by transpiration, including the evaporation of water within the leaf and diffusion of water vapour through stomata; interpret data from experiments relating to transpiration (B2.14)
spreadsheet	describe commercial applications of plant hormones: stimulating the growth of roots in cuttings; regulating the development of fruits; killing weeds by disrupting their normal growth pattern (B2.17)
Internet	describe how selective breeding is used to develop crop plants and agricultural animals with desirable characteristics such as resistance to disease and production of high yields (B3.20)
word-processing	describe how selective breeding is used to develop crop plants and agricultural animals with desirable characteristics such as resistance to disease and high yields (B3.20)
word-processing	understand the principles of interdependence, adaptation, competition and predation; explain how these factors influence the distribution and population sizes of organisms in a given terrestrial or aquatic environment (B4.01)
simulation	understand the principles of interdependence, adaptation, competition and predation; explain how these factors influence the distribution and population sizes of organisms in a given terrestrial or aquatic environment (B4.01)
simulation	describe the impact of human activity on the environment, including the pollution of air and of water; recall the effects of air pollutants (eg sulfur dioxide, carbon monoxide) and of water pollutants (eg sewage, nitrates and phosphates) (B4.02)
Internet	describe the impact of human activity on the environment, including the pollution of air and of water; recall the effects of air pollutants (eg sulfur dioxide, carbon monoxide) and of water pollutants (eg sewage, nitrates and phosphates) (B4.02)
Internet	relate the level of impact on the environment to population size, economic factors and industrial requirements (B4.03)
simulation	relate the level of impact on the environment to population size, economic factors and industrial requirements (B4.03)
word-processing	describe the effects of deforestation and overfishing; understand the importance of protecting natural populations (B4.04)
Internet	describe the effects of deforestation and overfishing; understand the importance of protecting natural populations (B4.04)

simulation	describe food chains quantitatively using pyramids of biomass (B4.05)
simulation	understand that energy is transferred through food chains and that energy and biomass are lost between trophic levels (B4.06)
database	calculate the relative atomic mass of an element from relative masses and abundances of its isotopes (C1.06)
database	understand that the periodic table shows elements in order of increasing atomic number, arranged in rows (periods) (C3.02)
simulation	relate the uses of noble gases to their physical properties and lack of chemical reactivity (C3.08)
spreadsheet	describe the relative reactivity of the alkali metals as exemplified by their reaction with water (C3.11)
simulation	relate the uses of titanium, iron and copper to their properties (C3.20)
simulation	recall how the way in which a particular metal is extracted from its ores is related to its position in the reactivity series (C4.04)
word-processing	describe the extraction of aluminium from purified bauxite including simple cell diagram, nature of electrolyte and electrodes, and reactions (C4.06)
word-processing	describe the extraction of iron in the blast furnace, including outline diagram, raw materials, reactions and the formation and uses of slag (C4.09)
word-processing	recall the uses of the main fractions (gases, petrol, naphtha, kerosene, diesel oil, fuel oil, bitumen) (C4.14)
spreadsheet	recall the uses of the main fractions (gases, petrol, naphtha, kerosene, diesel oil, fuel oil, bitumen) (C4.14)
simulation	recall that the rates of chemical reactions vary from very fast, explosive reactions to very slow reactions which form no detectable products (C5.01)
datalogging	define enzymes as catalysts in biological systems and describe their use in washing powder, and food and drink manufacture (C5.07)
spreadsheet	define enzymes as catalysts in biological systems and describe their use in washing powder, and food and drink manufacture (C5.07)
word-processing	define enzymes as catalysts in biological systems and describe their use in washing powder, and food and drink manufacture (C5.07)
Internet	define enzymes as catalysts in biological systems and describe their use in washing powder, and food and drink manufacture (C5.07)
Internet	understand that the process of leaching of artificial fertilisers causes excessive plant growth in rivers and lakes and may be harmful to health (C6.07)

word-processing	explain how the carbon cycle helps to maintain atmospheric composition, ie carbon dioxide is added to the atmosphere by respiration and combustion and removed by photosynthesis and dissolving in water (C6.13)
spreadsheet	recall and use the quantitative relationship between power, current and voltage: power = current × voltage $P = I \times V$ and apply the above relationship to the selection of appropriate fuses (P1.07)
spreadsheet	calculate the energy used by domestic appliances in kilowatt-hours and calculate domestic electricity bills, based on meter readings (P1.08)
simulation	describe how current varies with voltage in wires, resistors, metal filament lamps and diodes and how this can be investigated experimentally (P1.13)
graphical	recall and use the quantitative relationship between voltage, current and resistance: voltage = current × resistance $V = I \times R$ (P1.16)
spreadsheet	recall that there are forces of attraction between unlike charges and repulsion between like charges (P1.25)
word-processing	describe the potential dangers and uses of electrostatic charges generated in everyday situations, eg fuelling aircraft and tankers, photocopiers and inkjet printers (P1.27)
spreadsheet	recall and use the quantitative relationship between acceleration, velocity and time: $\text{acceleration} = \frac{\text{change in velocity}}{\text{time taken}}$ $a = \frac{(v - u)}{t}$ (P2.04)
datalogging	interpret speed-time graphs and determine acceleration from the gradient of the graph (P2.05)
graphical	interpret speed-time graphs and determine acceleration from the gradient of the graph (P2.05)
word-processing	recall a brief history of our understanding of forces including: the Greek view – a single force needed to sustain motion; Galileo and Newton – balanced forces allow an object to continue in uniform motion in a straight line or to remain at rest; Newton – gravitational attraction acts between all masses (P2.07)
spreadsheet	recall and use the quantitative relationship between unbalanced force, mass and acceleration and apply this relationship to vehicular and human movement force = mass × acceleration $F = m \times a$ (P2.11)
simulation	understand that the stopping distance of a vehicle is the sum of the thinking distance and the stopping distance (P2.15)
datalogging	describe the factors affecting vehicle stopping distances including speed, mass, road condition and reaction time (P2.16)
spreadsheet	understand that the upward forces on a light beam supported at its ends vary with the position of a heavy object placed on the beam (P2.17)
Internet	• recall some uses of electromagnetic radiations including: – radio waves: broadcasting and communications – microwaves: cooking and satellite transmissions – infra-red: heaters, grills, night vision and remote controls – visible light: optical fibres and photography – ultraviolet: sunbeds, crime prevention and fluorescent lamps

	– X-rays: observing the internal structure of objects and materials, medical applications – gamma rays: sterilising food and medical equipment (P3.14).
word-processing	understand the difference between analogue and digital signals (P3.18)
simulation	describe the differences between the orbits of a planet and a moon, and also of a comet, and describe the different types of orbit of satellites around the Earth (P4.02)
Internet	recall that the Sun is one of many millions of stars in a huge group called the Milky Way galaxy (P4.04)
word-processing	understand a range of energy transfer chains illustrating the environmental implications of generating electricity, including: • the use of wind and water • geothermal resources • solar heating systems and electricity production through solar cells • fossil fuel reserves • nuclear power (P5.14)
database/ Internet	understand that the activity of a radioactive source decreases over a period of time and is measured in becquerels (P6.09) recall the term half-life and understand that it is different for different radioactive isotopes (P6.10) use the concept of half-life to carry out simple calculations on activity (P6.11) describe the uses of radioactivity in medical and non-medical tracers, in radiotherapy and in the radioactive dating of archaeological specimens and rocks (P6.12)
word-processing	describe the uses of radioactivity in medical and non-medical tracers, in radiotherapy and in the radioactive dating of archaeological specimens and rocks (P6.12)

This specification may be used to address the key skill information technology. Further details are given in *Appendix 1*, page 92.

Environmental education

The development of environmental awareness through the teaching of the statements exemplified below will enable students to appreciate aspects of Local Agenda 21 and other environmental issues.

- understand that exposure to ionising radiation (including gamma rays, ultraviolet rays and X-rays) and some chemical mutagens (including chemicals in tobacco) increase the incidence of mutations (B3.13).
- describe how selective breeding is used to develop crop plants and agricultural animals with desirable characteristics such as resistance to disease and high yields (B3.20).
- describe the impact of human activity on the environment, including the pollution of air and of water; recall the effects of air pollutants (eg sulfur dioxide, carbon monoxide) and of water pollutants (eg sewage, nitrates and phosphates) (B4.02).
- relate the level of impact on the environment to population size, economic factors and industrial requirements (B4.03).

- describe the effects of deforestation and overfishing; understand the importance of protecting natural populations (B4.04).

explain the techniques used to maximise food production in terms of optimum feeding conditions, disease and predator control (B4.08)

describe the use of fluorides in the water supply and in toothpaste, of chlorine in water purification and of iodine as an antiseptic (C3.17)

recall and explain the formation of the products of the complete and incomplete combustion (oxidation) of hydrocarbons, and the possible effect of these on the environment (C4.15)

define enzymes as catalysts in biological systems and describe their use in washing powder, and food and drink manufacture (C5.07)

understand that the process of leaching of artificial fertilisers causes excessive plant growth in rivers and lakes and may be harmful to health (C6.07).

explain that the first primitive plants released oxygen as a result of photosynthesis and that the percentage of oxygen in the atmosphere gradually increased (C6.12)

understand that the presence of fossils in a rock is evidence that it has been formed from sediments (C6.16)

recall the hazards of electricity including frayed cables, long cables, damaged plugs, water around sockets and pushing metal objects into sockets (P1.03)

describe the uses of insulation, double insulation, earthing, fuses and circuit breakers in a range of domestic appliances (P1.04)

describe the potential dangers and uses of electrostatic charges generated in everyday situations, eg fuelling aircraft and tankers, photocopiers and inkjet printers (P1.27)

describe the factors affecting vehicle stopping distances including speed, mass, road condition and reaction time (P2.16)

recall some uses of electromagnetic radiations including:

- radio waves: broadcasting and communications
- microwaves: cooking and satellite transmissions
- infra-red: heaters, grills, night vision and remote controls
- visible light: optical fibres, photography
- ultraviolet: sunbeds, crime prevention and fluorescent lamps
- X-rays: observing the internal structure of objects and materials, medical applications
- gamma rays: sterilising food and medical equipment (P3.14).

- describe how insulation is used to reduce energy transfers from buildings and the human body (P5.06)
- understand a range of energy transfer chains illustrating the environmental implications of generating electricity, including:
  - the use of wind and water
  - geothermal resources
  - solar heating systems and electricity production through solar cells
  - fossil fuel reserves
  - nuclear power (P5.14)
- recall the existence of background radiation from the Earth and from space, including the regional variations in the United Kingdom, eg because of radon gas released from rocks (P6.08)
- describe the uses of radioactivity in medical and non-medical tracers, in radiotherapy and in the radioactive dating of archaeological specimens and rocks (P6.12)

Health and safety education

The following topics indicate content complementing the personal and social education programmes as set out in the National Curriculum.

- explain how vigorous exercise can result in an oxygen debt (B1.19)
- explain the role of insulin in regulating the level of blood sugar and its use in treating diabetes (B1.26)
- describe the harmful effects of: solvents on the lungs and nuerons; alcohol on reaction times, behaviour, liver and brain; smoking tobacco on the occurrence of bronchitis, emphysema, lung cancer and addiction to nicotine (B1.40)
- evaluate the use and misuse of drugs including antibiotics (eg penicillin), pain killers (eg aspirin and heroin), stimulants (eg caffeine and amphetamines), sedatives (eg barbiturates) and the dangers of contracting HIV and hepatitis by the use of intravenous drugs (B1.41)
- understand:
  - that genes exist in alternative forms (alleles) which cause variation in inherited characteristics
  - the terms dominant and recessive
  - that some alleles cause diseases which can be inherited (B3.05)
- understand that exposure to ionising radiation (including gamma rays, ultraviolet rays and X-rays) and some chemical mutagens (including chemicals in tobacco) increase the incidence of mutations (B3.13)
- describe the use of fluorides in the water supply and in toothpaste, of chlorine in water purification and of iodine as an antiseptic (C3.17)
- recall and explain the formation of the products of the complete and incomplete combustion (oxidation) of hydrocarbons, and the possible effect of these on the environment (C4.15)
- understand that the process of leaching of artificial fertilisers causes excessive plant growth in rivers and lakes and may be harmful to health (C6.07)

- recall the hazards of electricity including frayed cables, long cables, damaged plugs, water around sockets and pushing metal objects into sockets (P1.03)
- describe the uses of insulation, double insulation, earthing, fuses and circuit breakers in a range of domestic appliances (P1.04)
- describe the potential dangers and uses of electrostatic charges generated in everyday situations, eg fuelling aircraft and tankers, photocopiers and inkjet printers (P1.27)
- describe the factors affecting vehicle stopping distances including speed, mass, road condition and reaction time (P2.16)
- recall some uses of electromagnetic radiations including:
  - radio waves: broadcasting and communications
  - microwaves: cooking and satellite transmissions
  - infra-red: heaters, grills, night vision and remote controls
  - visible light: optical fibres, photography
  - ultraviolet: sunbeds, crime preventation and fluorescent lamps
  - X-rays: observing the internal structure of objects and materials, medical applications
  - gamma rays: sterilising food and medical equipment (P3.14)
- describe the uses of radioactivity in medical and non-medical tracers, in radiotherapy and in the radioactive dating of archaeological specimens and rocks (P6.12)
- describe the dangers of ionising radiations including:
  - radiation can cause mutations in living organisms
  - radiation can damage cells and tissue
  - the problems arising in the disposal of radioactive waste (P6.13).

In all aspects of experimental and investigative work candidates are required, in the context of implementing their proposed plans, to consider the safety of themselves and others. Centres are responsible for the overall risk assessment of experimental work undertaken by candidates.

European and global dimension

Many of the topics signposted for ideas and evidence in science provide a European and global dimension to scientific discoveries. This can be further enhanced by candidates accessing current developments through use of the Internet. This dimension is supported through understanding European legislation based on environmental and social issues.

Opportunities for the development of these issues may be found in the following sections:

- understand that exposure to ionising radiation (including gamma rays, ultraviolet rays and X-rays) and some chemical mutagens (including chemicals in tobacco) increase the incidence of mutations (B3.13)
- describe how selective breeding is used to develop crop plants and agricultural animals with desirable characteristics such as resistance to disease and high yields (B3.20)

- relate the level of impact on the environment to population size, economic factors and industrial requirements (B4.03)
- describe the effects of deforestation and overfishing; understand the importance of protecting natural populations (B4.04)
- recall and explain the formation of the products of the complete and incomplete combustion (oxidation) of hydrocarbons, and the possible effect of these on the environment (C4.15)
- understand that the process of leaching of artificial fertilisers causes excessive plant growth in rivers and lakes and may be harmful to health (C6.07)
  - recall some uses of electromagnetic radiations including:
  - radio waves: broadcasting and communications
  - microwaves: cooking and satellite transmissions
  - infra-red: heaters, grills, night vision and remote controls
  - visible light: optical fibres and photography
  - ultraviolet: sunbeds, crime prevention and fluorescent lamps
  - X-rays: observing the internal structure of objects and materials, medical applications
  - gamma rays: sterilising food and medical equipment (P3.14)
- recall the detrimental effects of excessive exposure of the human body to electromagnetic waves of increasing frequencies including:
  - microwaves: internal heating of body tissue
  - infra-red: skin burns
  - ultraviolet: damage to surface cells and blindness
  - gamma rays: cancer, mutation (P3.15)
- describe a variety of everyday and scientific devices and situations explaining the fate of the input energy in the above terms, including their representation by flow diagrams (Sankey diagrams) (P5.05).

Textbooks and other teaching resources

Edexcel Publications

Adamsway
Mansfield
Notts
NG18 4FN

Tel: 01623 467467
Fax: 01623 450481
E-mail: publications@linneydirect.com

Title	Order Code
Module 13: Micro-organisms and disease	To be published
Module 14: Biotechnology	To be published
Module 17: Communications	To be published
Module 18: Particles	To be published

Other publishers

Title	ISBN
Association for Science Education (ASE)	
Signs Symbols and Systematics: The ASE Companion to 5-16 Science	0 86357 232 4
Cambridge University Press	
Jones and Jones – *Biology*	0 521 45618 5
Jones and Jones – *Coordinated Science Biology* – 2nd Ed	0 521 59981 4
Jones, Jones and Acaster – *Coordinated Science Chemistry* – 2nd Ed	0 521 59983 0
Jones, Jones, Acaster and Marchington – *Balanced Science 1* – 2nd Ed	0 521 59979 2
Jones, Jones, Acaster and Marchington – *Balanced Science 2* – 2nd Ed	0 521 59980 6
Jones, Jones and Marchington – *Coordinated Science Physics* – 2nd Ed	0 521 59982 2
Harwood – *Chemistry*	0 521 576288
Norris – *Science Support Biology*	0 521 57915 5
Norris – *Science Support Chemistry*	0 521 57914 7
Norris – *Science Support Physics*	0 521 57913 9

Hodder and Stoughton

England – *Physics Matters* – 2nd Ed	0 340 63935 0
Hill – *Chemistry Counts* – 2nd Ed	0 340 63934 2
Hills and Butler – *Progress with GCSE Structured Questions: Chemistry*	0 340 72041 7
Hirst – *Progress with GCSE Structured Questions: Biology*	0 340 72043 3
Jenkins – *Complete GCSE Biology*	0340 73042 0
Keenan – *Progress with GCSE Structured Questions: Physics*	0 340 72042 5

Letts

Booth and McDuell – *GCSE Physics Questions and Answers*	1 857 58321 3
Callaghan and Jenkins – *GCSE Biology Questions and Answers*	1 857 58315 9
Ford-Robertson – *GCSE Biology Study Guide*	1 857 58300 0
Hill – *GCSE Science Study Guide*	1 857 58237 3
Jenkins – *GCSE Human Biology Study Guide*	1 857 58309 4
McDuell – *GCSE Chemistry Study Guide*	1 857 58302 7
McDuell and Booth – *GCSE Chemistry Questions and Answers*	1 857 58316 7
McDuell and Booth – *GCSE Science Questions and Answers*	1 857 58322 1
McDuell, Booth and Bayliss – *Science Classbook*	1 857 58416 3
McDuell, Booth and Bayliss – *Science Homework Book*	1 857 58417 1
Shepherd – *GCSE Physics Study Guide*	1 857 58310 8

Longman Co-ordinated Science

Biology Student's Book	0 582 27653 5
Physics Student's Book	0 582 27984 4
Chemistry Student's Book	0 582 27985 2

John Murray

Duncan – *GCSE Physics* – 3rd Ed	0 7195 5301 6
Earl and Wilford – *GCSE Chemistry*	0 7195 5303 2
Mackean – *GCSE Biology* – 2nd Ed	0 7195 5302 4
World of Science New SATIS Student's Book	0 7195 7411 0
World of Science New SATIS Teacher's Book	0 7195 7412 9

Robert Frost

Data Logging in practice	0 952 02574 4
The IT Science Book of Data Logging and Control	0 952 02571 X

Nelson Thornes

Avison – *The World of Physics*	0 17 438245 6
Dobson – *Nelson Balanced Science: The Physical World* – 2nd Ed	0 17 438699 0
Dobson – *Nelson Science: Physics*	0 17 438679 6
Hill and Holman – *Quickcheck GCSE Chemistry*	0 17 448152 7
Holman – *Nelson Balanced Science: The Material World* – 2nd Ed	0 17 438700 8
Holman – *Nelson Science: Chemistry*	0 17 438678 8
Lakin and Patefield – *Essential Science for GCSE*	0 17 438716 4
Roberts – *Biology for Life*	0 17 448096 2
Roberts – *Nelson Balanced Science: The Living World* – 2nd Ed	0 17 438701 6
Roberts – *Nelson Science: Biology*	0 17 438677 X
Roberts – *Quickcheck GCSE Biology*	0 17 448153 5
University of Bath Science 5-16: Life	
Materials	
Earth	
Movement	
Connections	

Nelson Thornes

Applin D – *Key Science Biology* (*New Edition Extension File*)	0 7487 3004 4
Applin D – *Key Science Biology* (*New Edition Student's Book)*	0 7487 3007 9
Breithaupt J – *Key Science Physics* (*New Edition Extension File)*	0 7487 3005 2
Breithaupt J – *Key Science Physics* (*New Edition Student's Book)*	0 7487 3008 7
Johnson K – *Physics for You* (*Student's Book)*	0 7487 2761 2
Johnson K – *Physics for You* (*Teacher's Support Pack)*	0 7487 2755 8
McDuell/Booth/Hirst – *Science: On Course for GCSE*	0 7487 3666 2
McDuell/Booth/Hirst – *Science: On Course for GCSE Teacher's Book*	0 7487 3669 7
Ramsden E – *Key Science Chemistry* (*New Edition Extension File)*	0 7487 3006 0
Ramsden E – *Key Science Chemistry* (*New Edition Student's Book)*	0 7487 3009 5
Ryan L – *Chemistry for You* (*Student's Book)*	0 7487 2367 6
Ryan L – *Chemistry for You* (*Teacher's Support Pack)*	0 7487 2757 4
Williams G – *Biology for You* (*Student's Book)*	0 7487 2366 8
Williams G – *Biology for You* (*Teacher's Support Pack*)	0 7487 2756 6

Chemical Industry Education Centre, University of York, York YO1 5DD

Recycling Cities

Wearing Jeans

Breathing Made Easy

Cash and Chemicals

Addresses of scientific organisations

Institute of Biology

Head of Education and Training
IofB
20 Queensberry Place
London
SW7 2DZ

Institute of Physics

Education Manager (Schools and Colleges)
Institute of Physics
76 Portland Place
London
W1N 3DH

National Centre for Biotechnology Education

Department of Microbiology
University of Reading
Whiteknights
Reading
RG6 2AJ

Royal Society of Chemistry

Education Manager (Schools and Colleges)
RSC
Burlington House
Piccadilly
London
W1V 0BN

Wellcome Trust

210 Euston Road
London
NW1 2BE

Schools Information Centre on the Irish Chemical Industry

Resources for Teaching Chemistry – 2nd Ed – (1994) – contains an extensive list of resources from companies and organisations in Ireland, the UK and overseas, with a guide to museums, interactive centres, periodicals, videos, software, safety etc.

Videos

Boulton-Hawker Films Ltd
Hadleigh near Ipswich
Suffolk
IP7 5BG

Chemical Cycles in the Biosphere

Cell-division – Mitosis and Meiosis

Pumping Life – The heart and circulatory system

Breath of Life – Our respiratory system

Genetic Engineering – Exploring the issues

University of York Science Education Group & Granada TV

Chemistry in Action: (Video Programmes with Student Sheets and Teachers' Guide)

Cracking the Problem: Manufacture of Ethene and Poly(ethene)

Salt Solution: Chemicals from Salt

Rusting all Over the World: Iron and Steel, Properties of Iron

Aluminium Can!: Properties of Aluminium

Invergrog Reservoir: Purification of Water

Limestone: Properties of Lime

Out of the Air: Air Pollution

Ways with Coal: Uses of Coal and Coke

Support and training

Training

A programme of INSET courses covering various aspects of the specifications and assessment will be arranged by Edexcel each year on a regional basis. Full details may be obtained from:

INSET
Edexcel Foundation
Stewart House
32 Russell Square
London WC1B 5DN

Tel: 020 7758 5620
Fax: 020 7758 5950
020 7758 5951 (second fax number)
E-mail: inset@edexcel.org.uk

Website

www.edexcel.org.uk

Please visit the Edexcel website, where further information about training and support for all qualifications, including this GCSE, can be found.

The website is regularly updated, and an increasing amount of support material and information will become available through it.

Edexcel Publications

Edexcel will provide a range of support materials for teachers in centres offering this specification.

This will include:

- amplification for the internal assessment of coursework
- examples of suitable experiments and investigations for assessment
- full analyses of some experiments and investigations as a guide to setting and marking activities
- examples of assessed candidates' work, showing how marks are awarded for the four skills areas of Sc1.

Support materials and further copies of this specification can be obtained from:

Edexcel Publications
Adamsway
Mansfield
Notts NG18 4FN

Tel: 01623 467467
Fax: 01623 450481
E-mail: publications@linneydirect.com

The following support materials will be available from spring 2001 onwards:

- specimen papers
- internal assessment guide
- teaching schemes

Regional Offices and Customer Response Centre

Further advice and guidance is available through a national network of regional offices. For general enquiries and for details of your nearest office please call the Edexcel Customer Response Centre on 0870 240 9800.

Appendices

Appendix 1 – Key skills

The GCSE in Science offers a range of opportunities for students to:

- develop their key skills
- generate assessed evidence for their portfolio.

In particular, the following key skills can be developed and assessed through this specification at level 2:

- application of number
- communication
- information technology
- improving own learning and performance
- working with others
- problem solving.

Copies of the key skills specifications can be ordered from Edexcel Publications.

The individual key skills units are divided into three parts:

- Part A: what you need to know – this identifies the underpinning knowledge and skills required of the student
- Part B: what you must do – this identifies the evidence that students must produce for their portfolio
- Part C: guidance – this gives examples of possible activities and types of evidence that may be generated.

This GCSE specification signposts development and internal assessment opportunities which are based on Part B of the level 2 key skills units. For those students working at level 1, these level 2 opportunities can also be used to generate evidence at level 1. Reference should be made to the appropriate level 1 statements in the key skills specifications.

The evidence generated through this GCSE will be internally assessed and contribute to the student's key skills portfolio. In addition, in order to achieve the key skills qualification, students will need to take the additional external tests associated with communication, information technology and application of number. Centres should check the current position on proxy qualifications as some students may be exempt from part or all of the assessment of a specific key skill.

Each section within the GCSE in Science will provide opportunities for the development of all six of the key skills identified. This appendix identifies the key skills evidence requirements and also provides a mapping of those opportunities. Students will need to have opportunities to develop their skills over time before they are ready for assessment. This appendix contains illustrative activities for each key skill that will aid development and facilitate the generation of appropriate portfolio evidence. To assist in the recording of key skills evidence Edexcel has produced recording documentation which can be ordered from Edexcel Publications.

Mapping of key skills: summary table

Key skills (level 2)	B1	B2	B3	B4	C1	C2	C3	C4	C5	C6	P1	P2	P3	P4	P5	P6
Application of number																
N2.1	✔	✔	✔	✔		✔	✔		✔			✔		✔	✔	✔
N2.2	✔	✔		✔		✔						✔		✔	✔	✔
N2.3	✔	✔		✔		✔						✔		✔	✔	✔
Communication																
C2.1a	✔	✔	✔	✔	✔		✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
C2.1b	✔	✔	✔	✔	✔		✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
C2.2	✔	✔	✔	✔	✔		✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
C2.3	✔	✔	✔	✔	✔		✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Information technology																
IT2.1	✔	✔	✔	✔	✔		✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
IT2.2	✔	✔	✔	✔	✔			✔	✔	✔	✔	✔	✔	✔	✔	✔
IT2.3	✔	✔	✔	✔	✔		✔	✔	✔	✔	✔	✔	✔	✔	✔	✔

Key skills (level 2)	B1	B2	B3	B4	C1	C2	C3	C4 (C2B)	C5 (C3B)	C6 (C2C)	P1	P2	P3	P4	P5	P6
Working with others																
WO2.1	✔	✔	✔	✔			✔	✔	✔	✔		✔	✔	✔	✔	✔
WO2.2	✔	✔	✔	✔			✔	✔	✔	✔		✔	✔	✔	✔	✔
WO2.3	✔	✔	✔	✔			✔	✔	✔	✔		✔	✔	✔	✔	✔
Improving own learning and performance																
LP2.1	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
LP2.2	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
LP2.3	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Problem solving																
PS2.1	✔	✔		✔					✔			✔			✔	
PS2.2	✔	✔		✔					✔			✔			✔	
PS2.3	✔	✔		✔					✔			✔			✔	

Application of number level 2

The GCSE in Science (linear) provides opportunities for students both to develop the key skill of application of number and also to generate evidence for their portfolio. As well as undertaking tasks related to the three areas of evidence required, students are also required to undertake a substantial activity that includes straightforward tasks. This will involve students obtaining and interpreting information, using this information when carrying out calculations, and interpreting and presenting the results of the calculations.

Key skill portfolio evidence requirement		GCSE section	Opportunities for development or internal assessment
N2.1	Interpret information from **two** different sources, including material containing a graph	B1-4, C2, C3, C5, P2 and P4-6	Students are required to obtain and use the information required; selecting appropriate methods to get the results required. Suitable subjects are: • Respiration experiments. B1 • Water loss from plants. B2 • Environmental and genetic variation. B3 • Distribution of organisms. B4 • Pollution and human survival. B4 • Calculations in chemistry. C2 • Properties and uses of transition metals. C3 • Speed – time graphs. P2 • Orbits. P4 • Radioactive decay. P6 • Penetration of ionising radiation. P6 Additionally, this whole key skill may be addressed through the means of a practical investigation. Suitable subjects for a practical investigation are: • Factors affecting the rate of photosynthesis. B2 • Distribution of organisms. B4 • Enzyme – catalysed reactions. C5 • Factors affecting rate of reaction. C5 • Factors affecting stopping distance. P2 • Force against extension for a range of materials. P2 • Current and voltage in various devices. P5

Key skill portfolio evidence requirement		GCSE section	Opportunities for development or internal assessment
N2.2	Carry out calculations to do with: a amounts and sizes b scales and proportions c handling statistics d using formulae.	B1, B2, B4, C2, P2 and P4-6	Students must carry out their calculations, which could relate to volumes, ratios, averages, formulae, etc, and show their methods of working. They must show how they have checked results and corrected their work as necessary. Suitable subjects are: • Respiration experiments. B1 • Water loss from plants. B2 • Distribution of organisms. B4 • Calculations in chemistry. C2 • Speed – time graphs. P2 • Orbits. P4 • Radioactive decay. P6 • Penetration of ionising radiation. P6 Additionally, this whole key skill may be addressed through the means of a practical investigation. Suitable subjects for a practical investigation are: • Factors affecting the rate of photosynthesis. B2 • Distribution of organisms. B4 • Enzyme – catalysed reactions. C5 • Factors affecting rate of reaction. C5 • Factors affecting stopping distance. P2 • Force against extension for a range of materials. P2 • Current and voltage in various devices. P5

Key skill portfolio evidence requirement		GCSE section	Opportunities for development or internal assessment
N2.3	Interpret results of your calculations and present your findings. You must use at least **one** graph, **one** chart and **one** diagram	B1, B2, B4, C2, P2 and P4-6	Based on their findings, students must select effective methods of presentation, using as appropriate tables, graphs, charts and diagrams. Students should explain how the results of their calculations meet the purpose of the activity undertaken. Suitable subjects are: • Respiration experiments. B1 • Water loss from plants. B2 • Distribution of organisms. B4 • Calculations in chemistry. C2 • Speed – time graphs. P2 • Orbits. P4 • Radioactive decay – P6 • Penetration of ionising radiation. P6 Additionally, this whole key skill may be addressed through the means of a practical investigation. Suitable subjects for a practical investigation are: • Factors affecting the rate of photosynthesis. B2 • Distribution of organisms. B4 • Enzyme – catalysed reactions. C5 • Factors affecting rate of reaction. C5 • Factors affecting stopping distance. P2 • Force against extension for a range of materials. P2 • Current and voltage in various devices. P5

Evidence

Students' evidence for application of number could include:

- description of the substantial activity
- copies of source materials
- records of calculations showing methods used
- descriptions of findings.

Communication level 2

For the communication key skill, students are required to hold discussions and give presentations, read and summarise information, and write documents. Students will be able to develop all of these skills through an appropriate teaching and learning programme based on this GCSE specification.

Key skill portfolio evidence requirement		GCSE section	Opportunities for development or internal assessment
C2.1a	Contribute to a discussion about a straightforward subject	B1-4, C1, C3-6 and P1-6	Many of the topics in this specification are suitable as the basis of a group discussion. The discussion should be about a straightforward subject. This may be a subject often met in their studies, etc and the vocabulary will be familiar. During the discussion students should make clear and relevant contributions, listen and respond to others, helping to move the discussion forward. Suitable subjects for discussion are: • The control of body temperature. B1 • Factors affecting the rate of photosynthesis. B2 • Environmental and genetic variation. B3 • Genetic disorders, gene therapy and genetic counselling. B3 • Pollution and human survival. B4 • Deforestation, the carbon cycle and sustainable growth. B4 • Bonding and the structure of materials. C1 • Properties and uses of transition metals. C3 • Uses of fractions from crude oil. C4 • The production and uses of polymers. C4 • Extraction of metals. C4 • Factors affecting rate of reaction. C5 • The atmosphere in balance and its history. C6 • The use and overuse of fertilisers. C6 • Uses and problems of electrostatics. P1 • Force against extension for a range of materials. P2 • Uses and problems of electromagnetic radiation. P3 • Digital versus analogue communication. P3 • The story of the universe. P4 • Current and voltage in various devices. P5 • Generation and use of electricity and sustainable growth. P5 • Radioactive half-life – its uses and the disposal of radioactive waste. P6

Key skill portfolio evidence requirement		GCSE section	Opportunities for development or internal assessment
C2.1b	Give a short talk about a straightforward subject, using an image	B1-4, C1, C3-6 and P1-6	Following a period of research students could be given the opportunity to give a short talk to the rest of their group. During the talk students should speak clearly in a way that suits the subject and situation. They should keep to the subject. The structure of the talk should help listeners follow points made. The talk should include an image to illustrate main points clearly. Images could include, charts, diagrams of apparatus and processes, molecular models and pictures. Each of the subjects suitable for a discussion are subjects suitable for the basis of a talk: • The control of body temperature. B1 • Factors affecting the rate of photosynthesis. B2 • Environmental and genetic variation. B3 • Genetic disorders, gene therapy and genetic counselling. B3 • Pollution and human survival. B4 • Deforestation, the carbon cycle and sustainable growth. B4 • Bonding and the structure of materials. C1 • Properties and uses of transition metals. C3 • Uses of fractions from crude oil. C4 • The production and uses of polymers. C4 • Extraction of metals. C4 • Factors affecting rate of reaction. C5 • The atmosphere in balance and its history. C6 • The use and overuse of fertilisers. C6 • Uses and problems of electrostatics. P1 • Force against extension for a range of materials. P2 • Uses and problems of electromagnetic radiation. P3 • Digital versus analogue communication. P3 • The story of the universe. P4 • Current and voltage in various devices. P5 • Generation and use of electricity and sustainable growth. P5 • Radioactive half-life – its uses and the disposal of radioactive waste. P6

Key skill portfolio evidence requirement		GCSE section	Opportunities for development or internal assessment
C2.2	Read and summarise information from **two** extended documents about a straightforward subject One of the documents should include at least **one** image	B1-4, C1, C3-6 and P1-6	Students will have a number of opportunities to read and synthesise information from two extended documents: for example, as part of their preparation for the discussion and talk, or as preparation for a piece of written work for their GCSE. Extended documents may include textbooks and reports and articles of more than three pages. At least one of these documents should contain an image from which students can draw appropriate and relevant information. Students will need to select and read relevant material. From this information they will need to identify accurately the lines of reasoning and main points from the text and images. Students will then need to summarise this information in a form that suits the purpose – eg for a talk, discussion or a presentation. Present opportunities for research. Each of the subjects suitable for a discussion or a talk will provide opportunities for research. The key skill IT may also be addressed alongside this aspect of this key skill. Suitable subjects are: • The control of body temperature. B1 • Factors affecting the rate of photosynthesis. B2 • Environmental and genetic variation. B3 • Pollution and human survival. B4 • Deforestation, the carbon cycle and sustainable growth. B4 • Bonding and the structure of materials. C1 • Properties and uses of transition metals. C3 • Uses of fractions from crude oil. C4 • The production and uses of polymers. C4 • Extraction of metals. C4 • Factors affecting rate of reaction. C5 • The atmosphere in balance and its history. C6 • The use and overuse of fertilisers. C6 • Uses and problems of electrostatics. P1 • Force against extension for a range of materials. P2 • Digital versus analogue communication. P3 • The story of the universe. P4 • Current and voltage in various devices. P5 • Generation and use of electricity and sustainable growth. P5 • Uses and dangers of ionising radiation. P6 • Radioactive half-life – its uses and the disposal of radioactive waste. P6

Key skill portfolio evidence requirement		GCSE section	Opportunities for development or internal assessment
C2.3	Write two different types of documents about straightforward subjects One piece of writing should be an extended document and include at least **one** image	B1-4, C1, C3-6 and P1-6	Students are required to produce two different types of document. At least one of these should be an extended document, for example a report of more than three pages. The document should present relevant information in an appropriate form. At least one of the documents should include an appropriate image that contains and effectively conveys relevant information. The information in the document should be clearly structured: eg through the use of headings, paragraphs, etc. Students should ensure that the text is legible and that spelling, punctuation and grammar are accurate. The two types of documents could be the basis of a presentation to the class and a project or practical work write-up presented to the teacher. Each of the subjects used for a talk or as a presentation will provide opportunities for the writing of documents. The key skill information technology may also be addressed alongside this aspect of this key skill. Suitable subjects are: • The control of body temperature. B1 • Factors affecting the rate of photosynthesis. B2 • Environmental and genetic variation. B3 • Genetic engineering and selective breeding. B3 • Pollution and human survival. B4 • Deforestation, the carbon cycle and sustainable growth. B4 • Bonding and the structure of materials. C1 • Properties and uses of transition metals. C3 • Uses of fractions from crude oil. C4 • The production and uses of polymers. C4 • Extraction of metals. C4 • Factors affecting rate of reaction. C5 • The atmosphere in balance and its history. C6 • The use and overuse of fertilisers. C6 • Uses and problems of electrostatics. P1 • Force against extension for a range of materials. P2 • Uses and problems of electromagnetic radiation P3 • Digital versus analogue communication. P3 • The story of the universe. P4 • Current and voltage in various devices. P5 • Generation and use of electricity and sustainable growth. P5 • Radioactive half-life – its uses and the disposal of radioactive waste. P6

Evidence

Student evidence for communication could include:

- tutor observation records
- preparatory notes
- audio/video tapes
- notes based on documents read
- essays.

Information technology level 2

When producing work for their GCSE in Science (linear) students will have numerous opportunities to use information technology. The Internet, CD ROM, etc could be used to collect information. Documents can be produced using relevant software and images may be incorporated in those documents. Early drafts of documents could be e-mailed to tutors for initial comments and feedback.

If students undertaking coursework as part of their GCSE in Science (linear) use information technology, they will have opportunities to generate evidence for all three sections identified in Part B of the key skills specification.

In addition, students will be able to use information technology to generate evidence for the communication key skill. For example, the extended document with images, required for C2.3, could be generated using appropriate software.

As part of their Science (linear) programme students may not be able to generate sufficient evidence required for this unit: for example, working with numbers through the use of a spreadsheet application, or some aspects of database use. In this situation, students may use stand-alone IT sessions for development and evidence generation and/or other parts of their GCSE course.

Key skill portfolio evidence requirement		**GCSE section**	**Opportunities for development or internal assessment**
IT2.1	Search for and select information for **two** different purposes	B1-4, C1, C3-6 and P1-6	Students will need to identify suitable sources of information and effectively search for information using multiple criteria. Information selected should be interpreted and students should decide what is relevant for their purpose. This key skill can be addressed along with communication by students undertaking research for a project or a practical activity. The two purposes could be a presentation to the class and a project or practical work write-up presented to the teacher. The key skill communication may also be addressed alongside this aspect of this key skill. Suitable subjects are: • The control of body temperature. B1 • Factors affecting the rate of photosynthesis. B2 • Environmental and genetic variation. B3 • Genetic modification and selective breeding. B3 • Genetic disorders, gene therapy and genetic counselling. B3 • Deforestation, the carbon cycle and sustainable growth. B4 • Bonding and the structure of materials. C1 • The production and uses of polymers. C4 • Crude oil and sustainable growth. C4 • Patterns of reactivity. C5 • Factors affecting rate of reaction. C5 • The atmosphere in balance and its history. C6

Key skill portfolio evidence requirement		GCSE section	Opportunities for development or internal assessment
			• The use and overuse of fertilisers. C6 • Uses and problems of electrostatics. P1 • Factors affecting stopping distance. P2 • Plate tectonics. P3 • The story of the universe. P4 • Current and voltage in various devices. P5 • Generation and use of electricity and sustainable growth. P5 • Uses and dangers of ionising radiation. P6 • Radioactive half-life – its uses and the disposal of radioactive waste. P6
IT2.2	Explore and develop information, and derive new information for **two** different purposes	B1-4, C1, C4-6 and P1-6	Students are required to bring together information in formats, such as tables, suitable for developing the information. The information should be explored by, for example, changing information in a spreadsheet model. Information should also be developed and new information derived as appropriate, for example through the use of headings, tables, charts and graphs. New information should be derived from, for example, comparing information from different sources, using formulae to perform calculations, or processes may be modelled using IT. The two purposes could be a presentation to the class and a project or practical work write-up presented to the teacher. Subjects in Section IT2.1 which are suitable for research are also suitable for this aspect of the key skill. The key skill communication may also be addressed alongside this aspect of this key skill. Suitable subjects are: • The control of body temperature. B1 • Factors affecting the rate of photosynthesis. B2 • Environmental and genetic variation. B3 • Genetic modification and selective breeding. B3 • Genetic disorders, gene therapy and genetic counselling. B3 • Deforestation, the carbon cycle and sustainable growth. B4 • Bonding and the structure of materials. C1 • The production and uses of polymers. C4 • Crude oil and sustainable growth. C4 • Patterns of reactivity. C5 • Factors affecting rate of reaction. C5 • The atmosphere in balance and its history. C6 • The use and overuse of fertilisers. C6 • Uses and problems of electrostatics. P1 • Factors affecting stopping distance. P2

Key skill portfolio evidence requirement		GCSE section	Opportunities for development or internal assessment
			• Plate tectonics. P3 • The story of the universe. P4 • Current and voltage in various devices. P5 • Generation and use of electricity and sustainable growth. P5 • Uses and dangers of ionising radiation. P6 • Radioactive half-life – its uses and the disposal of radioactive waste. P6 Additionally, the following subjects are suitable for modelling by means of spreadsheets, or modelling programs: • The control of water content. B1 • The control of body temperature. B1 • Factors affecting the rate of photosynthesis. B2 • Competition and predator-prey relationships. B4 • Pollution and human survival. B4 • Deforestation, the carbon cycle and sustainable growth. B4 • Crude oil and sustainable growth. C4 • The atmosphere in balance and its history. C6 • Rate of reaction. C5 • Factors effecting the yield of reversible reactions. C5 • Factors affecting stopping distance. P2 • Terminal speed. P2 • Unbalanced forces and acceleration. P2 • Digital versus analogue communication. P3 • The story of the universe. P4 • Current and voltage in various devices. P5 • Generation and use of electricity and sustainable growth. P5 • Radioactive half-life – its uses and the disposal of radioactive waste. P6
IT2.3	Present linear information for **two** different purposes. This work must include at least **one** example of text, **one** example of images and **one** example of numbers	B1-4, C1, C3-6 and P1-6	In presenting linear information students will need to select and use appropriate layouts in a consistent way through, for example, the use of margins, headings, borders, font size, etc. Layouts, etc, should be refined to suit both the purpose and the needs of the audience (early drafts should be kept as portfolio evidence). The final piece of work should be suitable for its purpose and audience eg GCSE coursework, OHTs/handouts for a presentation, etc. The document should have accurate spelling (use of spell-checker) and have been proof-read. The two purposes could be a presentation to the class and a project or practical work write-up presented to the teacher.

Key skill portfolio evidence requirement		GCSE section	Opportunities for development or internal assessment
			Subjects already identified as being suitable for the key skill information technology are also suitable for this aspect of information technology. The key skill communication may also be addressed alongside this aspect of this key skill. Suitable subjects are: • The control of body temperature. B1 • Factors affecting the rate of photosynthesis. B2 • Environmental and genetic variation. B3 • Genetic modification and selective breeding. B3 • Genetic disorders, gene therapy and genetic counselling. B3 • Deforestation, the carbon cycle and sustainable growth. B4 • Bonding and the structure of materials. C1 • The production and uses of polymers. C4 • Crude oil and sustainable growth. C4 • Patterns of reactivity. C5 • Factors affecting rate of reaction. C5 • The atmosphere in balance and its history. C6 • The use and overuse of fertilisers. C6 • Uses and problems of electrostatics. P1 • Factors affecting stopping distance. P2 • Plate tectonics. P3 • The story of the universe. P4 • Current and voltage in various devices. P5 • Generation and use of electricity and sustainable growth. P5 • Uses and dangers of ionising radiation. P6 • Radioactive half-life – its uses and the disposal of radioactive waste. P6

Evidence

Student evidence for information technology could include:

- tutor observation records
- notes of sources used
- print-outs with annotations
- draft documents.

Working with others level 2

To achieve this key skill, students are required to carry out at least two activities. One example must show that they can work in one-to-one situations and one example must show that they can work in group situations. Students will plan their work with others and confirm working arrangements; work co-operatively towards achieving identified objectives, and exchange information on progress.

Key skill portfolio evidence requirement		GCSE section	Opportunities for development or internal assessment
WO2.1	Plan straightforward work with others, identifying objectives and clarifying responsibilities, and confirm working arrangements	B1-4, C3-6 and P2-6	Students should identify the objectives of working together in groups to plan the successful completion of a set activity. Students should also identify the tasks, resources and timescales required to meet these objectives. Information should be exchanged to clarify responsibilities: for example, suggesting ways help can be given, asking what others can do, checking their own and others' responsibilities. The group needs to confirm responsibilities and working arrangements. A suitable activity could be a project, an experiment or a practice investigation. This key skill may be linear with other key skills: communication and information technology by including research and presentation as part of the activity; and additionally application of number if the activity is a practical activity. If this is done then students will need to have individually covered aspects of all the key skills involved. Suitable activities for all of this key skill are: • The use of drugs. B1 • Factors affecting the rate of photosynthesis. B2 • Genetic disorders, gene therapy and genetic counselling. B3 • Pollution and human survival. B4 • Deforestation, the carbon cycle and sustainable growth. B4 • Uses of fractions from crude oil. C4 • The production and uses of polymers. C4 • Extraction of metals. C4 • Enzyme – catalysed reactions. C5 • Factors affecting rate of reaction. C5 • The use and overuse of fertilisers. C6 • Factors affecting stopping distance. P2 • Force against extension for a range of materials. P2 • Uses and problems of electromagnetic radiation. P3 • The story of the universe. P4 • Generation and use of electricity and sustainable growth. P5 • Radioactive half-life – its uses and the disposal of radioactive waste. P6 • Uses and dangers of ionising radiation. P6

Key skill portfolio evidence requirement		GCSE section	Opportunities for development or internal assessment
WO2.2	Work co-operatively with others towards achieving identified objectives, organising tasks to meet responsibilities	B1-4, C3-6 and P2-6	When working towards agreed objectives students could work in pairs or small groups for project work and pairs for practical activities. Students will need to organise tasks so that responsibilities can be met, eg obtaining resources, completing tasks on time, etc. For example, whilst one student is researching for a project, another can be working on its presentation, or proof-reading an earlier draft; or one student could clear away apparatus from a previous stage of an investigation whilst the other is beginning the next stage. Tasks should be completed accurately and safely. Co-operative ways of working should be supported through, for example, anticipating the needs of others, avoiding actions that offend, etc. Advice from others, including group members, tutor, etc should be sought when needed. Students will need to plan and organise their work effectively so that they meet agreed deadlines and maintain appropriate working relationships. Suitable subjects are: • The use of drugs. B1 • Factors affecting the rate of photosynthesis. B2 • Genetic disorders, gene therapy and genetic counselling. B3 • Pollution and human survival. B4 • Deforestation, the carbon cycle and sustainable growth. B4 • Uses of fractions from crude oil. C4 • The production and uses of polymers. C4 • Extraction of metals. C4 • Enzyme – catalysed reactions. C5 • Factors affecting rate of reaction. C5 • The use and overuse of fertilisers. C6 • Factors affecting stopping distance. P2 • Force against extension for a range of materials. P2 • Uses and problems of electromagnetic radiation. P3 • The story of the universe. P4 • Generation and use of electricity and sustainable growth. P5 • Radioactive half-life – its uses and the disposal of radioactive waste. P6 • Uses and dangers of ionising radiation. P6

Key skill portfolio evidence requirement		GCSE section	Opportunities for development or internal assessment
WO2.3	Exchange information on progress and agree ways of improving work with others to help achieve objectives	B1-4, C3-6 and P2-6	Once completed, the full group needs to review outcomes against the agreed objectives. In doing this they should identify what has gone well and what has gone less well. Students should listen and respond to progress reports from others and agree ways of improving work with others to help achieve objectives. Students should identify areas of the exercise that could be improved and should suggest ways in which the group or pair could have worked differently and perhaps more effectively. Suitable subjects are: • The use of drugs. B1 • Factors affecting the rate of photosynthesis. B2 • Genetic disorders, gene therapy and genetic counselling. B3 • Pollution and human survival. B4 • Deforestation, the carbon cycle and sustainable growth. B4 • Uses of fractions from crude oil. C4 • The production and uses of polymers. C4 • Extraction of metals. C4 • Enzyme – catalysed reactions. C5 • Factors affecting rate of reaction. C5 • The use and overuse of fertilisers. C6 • Factors affecting stopping distance. P2 • Force against extension for a range of materials. P2 • Uses and problems of electromagnetic radiation. P3 • The story of the universe. P4 • Generation and use of electricity and sustainable growth. P5 • Radioactive half-life – its uses and the disposal of radioactive waste. P6 • Uses and dangers of ionising radiation. P6

Evidence

Student evidence for working with others could include:

- tutor observation records
- preparatory notes
- records of process and progress made.

Improving own learning and performance level 2

Within GCSEs in Science (linear) programmes, students will have opportunities to develop and generate evidence that meets part of the evidence requirement of this key skill.

To achieve this key skill, students will need to provide at least two examples of meeting the standard required. Students are also required to improve their performance through studying a straightforward subject and through learning through a straightforward practical activity. This GCSE in Science (linear) will provide opportunities for students to study a straightforward subject. Evidence for learning through a practical activity may come from other GCSEs in the students' programme or from enrichment activities.

Activities that generate evidence for this skill should take place over a period of a few weeks. Over the period of the activity there will be times when the students should work without close supervision. However, students should seek and receive feedback, from tutors and others, on their target setting and performance.

Any project work (including coursework) is a suitable learning activity and may be used to generate evidence for this key skill.

Key skill portfolio evidence requirement		GCSE section	Opportunities for development or internal assessment
LP2.1	Help set short-term targets with an appropriate person and plan how these will be met	B1-4, C1-6 and P1-6	Students could draw up a plan to show how they intend to cover the assignments, tests and practice examination papers in their preparation for a test. They will set realistic dates and targets in consultation with their tutor. They will identify potential problems and suggest alternative courses of action.
LP2.2	Take some responsibility for some decisions about your learning, using your plan and support from others to help meet targets. Improve your performance by: • studying a straightforward subject • learning through a straightforward practical activity.	B1-4, C1-6 and P1-6	Students will use their plan to meet targets and work effectively. This may involve prioritising tasks, managing their time effectively and amending their plan as necessary. Students will seek and use feedback from their tutor to help them improve their learning and performance. This may involve repeating a task or attempting a closely related one. Students may need to use different approaches to learning. These could include information technology-based tutorial material, pairing up with another student to review work, sharing tasks with other students or use of learning resource centres.
LP2.3	Review progress with an appropriate person and provide evidence of your achievements, including how you have used learning from one task or activity to meet the demands of a new task	B1-4, C1-6 and P1-6	Students should review their own progress and the quality of their learning and performance. They should be aware of the likely outcome if they are failing to meet targets or to make progress. Students may need to take remedial action and to seek help in an attempt to improve their performance. This may require an action plan to be drawn up and implemented.

Evidence

Student evidence for improving own learning and performance could include:

- tutor records
- annotated action plans
- records of discussions
- learning log
- work produced.

Problem solving level 2

To achieve this key skill, students will need to provide at least two examples of meeting the standard required. They need to show that they can identify problems, plan and try out options, check whether the problem has been solved. For this GCSE, students may not be able to try out options and check results as there may be difficulties in implementing practical solutions in a school or college context.

Key skill portfolio evidence requirement		GCSE section	Opportunities for development or internal assessment
PS2.1	Identify a problem and come up with **two** options for solving it	B1, B2, B4, C5, P2 and P5	As part of their programme of practical work, students could be given the problem to investigate. Students could work alone or in teams to suggest different ways of solving the problem. They would recognise that the problem is complex and that no simple solution identifying the substance is possible. They would select and use appropriate scientific methods for exploring the problem and describe its main features. Students would have to agree the standards to be met to show that the problem has been addressed and analysed to the required degree of precision and accuracy. It is likely that a suitable activity for this would be a practical investigation and all aspects of this key skill would be addressed together. Suitable subjects are: • Osmosis. B1 • Factors affecting the rate of photosynthesis. B2 • Distribution of organisms. B4 • Enzyme – catalysed reactions. C5 • Patterns of reactivity. C5 • Factors affecting rate of reaction. C5 • Factors affecting stopping distance. P2 • Falling objects and terminal speed. P2 • Unbalanced forces and acceleration. P2 • Force against extension for a range of materials. P2 • Current and voltage in various devices. P5

Key skill portfolio evidence requirement		GCSE section	Opportunities for development or internal assessment
PS2.2	Plan and try out at least **one** option for solving the problem, obtaining support and making changes to your plan when needed	B1, B2, B4, C5, P2 and P5	Students would be expected to generate at least two options for tackling the problem. They would compare the main features of each option including materials and apparatus requirements, time-scales to carry out the exercise, and health and safety factors. Students would select the option that has the most realistic chance of success, and justify their choice. It is most likely that a suitable activity for this would be a practical investigation and all aspects of this key skill would be addressed together. Suitable subjects are: • Osmosis. B1 • Factors affecting the rate of photosynthesis. B2 • Distribution of organisms. B4 • Enzyme – catalysed reactions. C5 • Patterns of reactivity. C5 • Factors affecting rate of reaction. C5 • Factors affecting stopping distance. P2 • Falling objects and terminal speed. P2 • Unbalanced forces and acceleration. P2 • Force against extension for a range of materials. P2 • Current and voltage in various devices. P5

Key skill portfolio evidence requirement		GCSE section	Opportunities for development or internal assessment
PS2.3	Check if the problem has been solved by applying given methods, describe results and explain your approach to problem solving	B1, B2, B4, C5, P2 and P5	For a laboratory-based problem students would have to draw up detailed plans for quantities of materials and apparatus required. They could carry out a risk assessment before obtaining permission to go ahead with their experiments. Students would carry out their plan, using support and feedback from others, including their tutor. Progress would be reviewed. The plan may have to be revised as the experiment or investigation progresses. It is most likely that a suitable activity for this would be a practical investigation and all aspects of this key skill would be addressed together. Suitable subjects are: • Osmosis. B1 • Factors affecting the rate of photosynthesis. B2 • Distribution of organisms. B4 • Enzyme – catalysed reactions. C5 • Patterns of reactivity. C5 • Factors affecting rate of reaction. C5 • Factors affecting stopping distance. P2 • Falling objects and terminal speed. P2 • Unbalanced forces and acceleration. P2 • Force against extension for a range of materials. P2 • Current and voltage in various devices. P5

Evidence

Student evidence for problem solving could include:

- description of the problem
- tutor records and agreement of standards and approaches
- annotated action plans
- records of discussions
- descriptions of options
- records of review.

Appendix 2 – Procedures for moderation of internal assessment

All centres will receive Optically-read Teacher Examiner Mark Sheets (OPTEMS) for each coursework component.

Centres will have the option of:

EITHER

recording marks on an Optically-read Teacher Examiner Mark Sheet (OPTEMS), Section 1

OR

recording marks on computer for transfer to Edexcel by means of Electronic Data Interchange (EDI), Section 2.

Sections 3 and 4 apply whichever option is selected and deal with Final Mark Aggregation Sheets and the sample of work required for moderation.

Section 1: Centres using OPTEMS

1.1 OPTEMS will be pre-printed on three-part stationery with unit and paper number, centre details and candidate names in candidate number order. A number of blank OPTEMS for candidates not listed will also be supplied.

The top copy is designed so that the marks can be read directly by an Optical Mark Reader. It is important therefore to complete the OPTEMS carefully in accordance with the instructions below. **Please do not fold or crease the sheets**.

1.2 Before completing the OPTEMS please check the subject, paper and centre details, to ensure the correct sheet is being completed.

1.3 All candidates entered by the deadline date will be listed on the OPTEMS, except those carrying forward their centre-assessed marks from the previous year. Such candidates will be listed on a separate OPTEMS coded T for Transferred. Any OPTEMS coded T should be checked, signed to confirm the transfer, and the top copy returned to Edexcel. No mark should be entered.

1.4 Late entries will need to be added in pencil either in additional spaces on the pre-printed OPTEMS or on one of the blank OPTEMS which will be supplied. Please note that full details of the centre, specification/unit, paper, candidates' names and candidate numbers must be added to ALL blank OPTEMS.

1.5 The OPTEMS should be completed **using an HB pencil.** Please ensure that you work on a firm flat surface and that figures written in the marks box go through to the second and third copies.

1.6 For each candidate, first ensure you have checked the arithmetic on the Final Mark Aggregation Sheet, then transfer the **Total Mark** to the box of the OPTEMS labelled 'Marks' for the correct candidate (please see exemplar page 118).

1.7 Encode the mark on the right-hand side by drawing a line to show the appropriate marks. Clear, dark **HB pencil** lines must be made but they must not extend beyond the limit of the box at the mark. Take care to remember the trailing zeros for candidates scoring 10, 20 etc and the leading zero for single figures, as shown.

1.8 If you make a mistake rub out the incorrect marks completely. Amend the number in the marks box and in the encoded section, but **please remember to amend separately the second and third copies** to ensure that the correct mark is clear.

1.9 Every candidate listed on the OPTEMS must have **either** a mark **or** one of the following codes in the marks box.

a 0 (zero marks) should be entered only if work submitted has been found to be worthless. It should **not** be used where candidates have failed to submit work.

b ABS in the marks box and an A in the encoded section for any candidate who has been absent or has failed to submit any work, even if an aegrotat award has been requested.

c W should be entered in the marks box and the encoded section where the candidate has been withdrawn.

Exemplar

			Encoded section											
Candidate name	**Number**	**Marks**												
NEW ALAN SP	*3200	0	~~(•0•)~~ ~~(•0•)~~	(•10•) (•1•)	(•20•) (•2•)	(•30•) (•3•)	(•40•) (•4•)	(•50•) (•5•)	(•60•) (•6•)	(•70•) (•7•)	(•80•) (•8•)	(•90•) (•9•)	(•100•) (•A•)	(•200•) (•W•)
OTHER AMY SP	*3201	5	~~(•0•)~~ (•0•)	(•10•) (•1•)	(•20•) (•2•)	(•30•) (•3•)	(•40•) (•4•)	(•50•) ~~(•5•)~~	(•60•) (•6•)	(•70•) (•7•)	(•80•) (•8•)	(•90•) (•9•)	(•100•) (•A•)	(•200•) (•W•)
SMITH JOHN AW	3202	47	(•0•) (•0•)	(•10•) (•1•)	(•20•) (•2•)	(•30•) (•3•)	~~(•40•)~~ (•4•)	(•50•) (•5•)	(•60•) (•6•)	(•70•) ~~(•7•)~~	(•80•) (•8•)	(•90•) (•9•)	(•100•) (•A•)	(•200•) (•W•)
WATTS MARK SP	*3203	ABS	(•0•) (•0•)	(•10•) (•1•)	(•20•) (•2•)	(•30•) (•3•)	(•40•) (•4•)	(•50•) (•5•)	(•60•) (•6•)	(•70•) (•7•)	(•80•) (•8•)	(•90•) (•9•)	(•100•) ~~(•A•)~~	(•200•) (•W•)
STEVEN JANE AW	3204	36	(•0•) (•0•)	(•10•) (•1•)	(•20•) (•2•)	~~(•30•)~~ (•3•)	(•40•) (•4•)	(•50•) (•5•)	(•60•) ~~(•6•)~~	(•70•) (•7•)	(•80•) (•8•)	(•90•) (•9•)		(•200•) (•W•)
JONES ANN AW	*3205	40	(•0•) ~~(•0•)~~	(•10•) (•1•)	(•20•) (•2•)	(•30•) (•3•)	~~(•40•)~~ (•4•)	(•50•) (•5•)	(•60•) (•6•)	(•70•) (•7•)	(•80•) (•8•)	(•90•) (•9•)	(•100•) (•A•)	(•200•) (•W•)
WEST SARA SP	3207	W	(•0•) (•0•)	(•10•) (•1•)	(•20•) (•2•)	(•30•) (•3•)	(•40•) (•4•)	(•50•) (•5•)	(•60•) (•6•)	(•70•) (•7•)	(•80•) (•8•)	(•90•) (•9•)	(•100•) (•A•)	(•200•) ~~(•W•)~~

1.10 Where more than one teacher has assessed the work, the teachers' initials should be given to the right of each candidate's name as illustrated.

1.11 The authentication and internal standardisation statement on the OPTEMS must be signed. **Centres are reminded that it is their responsibility to ensure that internal standardisation of the marking has been carried out**.

1.12 Once completed and signed the three-part sets should then be divided and despatched, or retained as follows:

a **top copy** to be returned direct to Edexcel in the envelope provided **to be received by 1 May for the May/June examination series**. Please remember this form **must not be folded or creased**.

b **second copy** to be sent **with the sampled coursework** as appropriate (see Section 4) to the moderator. The name and address of the moderator will either be printed on the OPTEMS or supplied separately.

c **third copy** to be retained by the centre.

Section 2: Centres using EDI

2.1 Marks must be recorded on computer and transmitted to Edexcel by **1 May for the May/June examination series**. They must be recorded in accordance with the specifications in the booklet *Formats for the Exchange of Examination Related Data using Microcomputers*. Each mark has a status as well as a value. Status codes are:

V – valid non-zero mark recorded; candidate not pre-selected as part of the sample for moderation

S – valid non-zero mark recorded and candidate included in sample for moderation (refer to OPTEMS and Section 4)

Z – zero mark recorded for work submitted

N – no work submitted but candidate **not** absent

A – absent for component

M – missing mark; no information available about the candidate's previous performance

F– mark carried forward from a previous examination series. (If the mark status is 'F', then no mark follows.)

The OPTEMS provided will indicate, with asterisks, the candidates whose work is to be sampled, where this is pre-selected (see Section 4).

2.2 **Printout**

Centres are required to produce a printout of the centre-assessed marks and annotate it as described below, before forwarding it **together with the sampled coursework** as appropriate (see Section 4) to the moderator, **to be received by 1 May for the May/June examination series**. The name and address of the moderator will either be printed on the OPTEMS or supplied separately.

ABS – absent

W – withdrawn

* – sampled candidate

✔ – additional sampled candidates.

Where more than one teacher has assessed the work the teachers' initials or the set number should be given beside each candidate's name.

Centres are reminded that it is their responsibility to ensure that internal standardisation of the marking is carried out. The following **authentication** and internal standardisation statement should be written at the bottom of the printout and signed by the teacher responsible:

'*I declare that the work of each candidate for whom marks are listed is, to the best of my knowledge, the candidate's own and that where several teaching groups are involved the marking has been internally standardised to ensure consistency across groups*.'

Signed . . . . . Date . . . . . .

Centres are advised to retain a copy of the annotated printout.

Section 3: Final Mark Aggregation Sheets (FIMAS)

A copy of the Final Mark Aggregation Sheet is provided on *Appendix 3*, page 121 for centres to photocopy. The FIMAS, to be completed for each candidate, provides details for the moderator of how each candidate's total mark is reached. It is the teacher's responsibility to ensure that:

- all marks are recorded accurately and that the arithmetic is correct
- the total mark is transferred correctly onto the OPTEMS or via EDI.

Where a candidate's work is included in the sample the FIMAS should be attached to the work.

Section 4: Sample of work for moderation

4.1 **Where the pre-printed OPTEMS is asterisked** indicating the candidates whose work is to be sampled, this work, together with the second copy of the OPTEMS, should be posted to reach the moderator by 1 May for candidates seeking certification in the summer series. The name and address of the moderator will either be printed on the OPTEMS or supplied separately.

In addition, the centre must send the work of the candidate awarded the **highest** mark and the work of the candidate awarded the **lowest** mark, if these are not already included within the initial samples selected. The centre should indicate the additional samples by means of a tick (✔) in the left-hand column against the names of each of the candidates concerned.

For all sampled work the associated FIMAS must be attached to each candidate's work.

If the pre-selected sample does NOT adequately represent ALL parts of the entire mark range for the centre, additional samples in the range(s) not covered should also be sent to the moderator. As above, additional samples should be indicated by means of a tick (✔).

For centres submitting marks by EDI the candidates in the sample selected on the OPTEMS should be marked with an asterisk (*) or a tick (✔), as appropriate, on the EDI printout. The annotated printout must be sent to the moderator with the sample of work.

4.2 **In all cases** please note that the moderator may request further samples of coursework, as required, and the work of all candidates should be readily available in the event of such a request.

Internal standardisation

Centres are reminded that it is their responsibility to ensure that where more than one teacher has marked the work, internal standardisation has been carried out. This procedure ensures that the work of all candidates at the centre is marked to the same standards. The statement confirming this on the OPTEMS or the EDI printout must be signed.

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Appendix 3 – Final Mark Aggregation Sheet

Year of examination:	Specification title:
Specification number:	
Centre:	Candidate name:
	Teaching group:
Centre number:	Candidate number:

Marks should be reported for each of the skill areas P, O, A and E.

Single Award and Separate Sciences

One mark is required for **each** skill area. Thus four marks are required in total to give a maximum mark of 30. These marks should be drawn from **not more than two** pieces of work. At least **one** mark must be from a practically based whole investigation. For single award, all marks may be drawn from one attainment target.

Double Award

Two marks are required for **each** skill area. Thus eight marks are required in total to give a maximum mark of 60. These marks should be drawn from **not more than four** pieces of work. At least **one** mark must be from a practically based whole investigation. At least two of the attainment targets must be represented.

The reported marks from each activity should be ringed.

Activity title(s)	P	O	A	E

Please indicate whether the reported mark(s) are taken from an investigation by putting an asterisk next to the appropriate mark(s).

The skill area marks are reported in the appropriate Centre Mark boxes in the table below and then aggregated to give a total reported mark.

	Skill area P		Skill area O		Skill area A		Skill area E		Total mark	Max mark
Centre mark (Single Award or Separate Science)										30
Centre mark (Double Award)										60
Moderator mark										
Team leader mark										

THE PERIODIC TABLE

Period	Group 1	2											3	4	5	6	7	8
1	1 H Hydrogen 1																	2 He Helium 4
2	3 Li Lithium 7	4 Be Berylium 9											5 B Boron 11	6 C Carbon 12	7 N Nitrogen 14	8 O Oxygen 16	9 F Fluorine 19	10 Ne Neon 20
3	11 Na Sodium 23	12 Mg Magnesium 24											13 Al Aluminium 27	14 Si Silicon 28	15 P Phosphorus 31	16 S Sulphur 32	17 Cl Chlorine 35.5	18 Ar Argon 40
4	19 K Potassium 39	20 Ca Calcium 40	21 Sc Scandium 45	22 Ti Titanium 48	23 V Vanadium 51	24 Cr Chromium 52	25 Mn Manganese 55	26 Fe Iron 56	27 Co Cobalt 59	28 Ni Nickel 59	29 Cu Copper 63.5	30 Zn Zinc 65.4	31 Ga Gallium 70	32 Ge Germanium 73	33 As Arsenic 75	34 Se Selenium 79	35 Br Bromine 80	36 Kr Krypton 84
5	37 Rb Rubidium 85	38 Sr Strontium 88	39 Y Yttrium 89	40 Zr Zirconium 91	41 Nb Niobium 93	42 Mo Molybdenum 96	43 Tc Technetium (99)	44 Ru Ruthenium 101	45 Rh Rhodium 103	46 Pd Palladium 106	47 Ag Silver 108	48 Cd Cadmium 112	49 In Indium 115	50 Sn Tin 119	51 Sb Antimony 122	52 Te Tellurium 128	53 I Iodine 127	54 Xe Xenon 131
6	55 Cs Caesium 133	56 Ba Barium 137	57 La ▶ Lanthanum 139	72 Hf Hafnium 178	73 Ta Tantalum 181	74 W Tungsten 184	75 Re Rhenium 186	76 Os Osmium 190	77 Ir Iridium 192	78 Pt Platinum 195	79 Au Gold 197	80 Hg Mercury 201	81 Tl Thallium 204	82 Pb Lead 207	83 Bi Bismuth 209	84 Po Polonium (210)	85 At Astatine (210)	86 Rn Radon (222)
7	87 Fr Francium (223)	88 Ra Radium (226)	89 Ac ▶▶ Actinium (227)	104 Unq Unnilquadium (261)	105 Unp Unnilpentium (262)	106 Unh Unnilhexium (263)												

key

Atomic Number
Symbol
Name
Molar mass in g mol^{-1}

58 Ce Cerium 140	59 Pr Praseo-dymium 141	60 Nd Neodymium 144	61 Pm Promethium (147)	62 Sm Samarium 150	63 Eu Europium 152	64 Gd Gadolinium 157	65 Tb Terbium 159	66 Dy Dysprosium 163	67 Ho Holmium 165	68 Er Erbium 167	69 Tm Thulium 169	70 Yb Ytterbium 173	71 Lu Lutetium 175
90 Th Thorium 232	91 Pa Protactinium (231)	92 U Uranium 238	93 Np Neptunium (237)	94 Pu Plutonium (242)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (245)	98 Cf Californium (251)	99 Es Einsteinium (254)	100 Fm Fermium (253)	101 Md Mendelevium (256)	102 No Nobelium (254)	103 Lr Lawrencium (257)

Appendix 5 – Subject specific requirements

Units and nomenclature

In the written papers and tests, the units and the nomenclature used will conform to the recommendations contained in the following booklets:

Biological Nomenclature: Recommendations on Terms, Units and Symbols (Institute of Biology (IOB), 1999)

Signs, Symbols and Systematics, The ASE Companion to 16-19 Science – 1st Ed (Association for Science Education (ASE), 2000).

Appendix 6 – Formulae for relationships

The GCSE Criteria for science issued by QCA specify that certain relationships and formulae should not be provided to students in examinations. This is mandatory for all awarding bodies.

The relationships listed below will *not* be provided for GCSE students either in the form given or in re-arranged form.

(i) the relationship between speed, distance and time:

$$speed = \frac{distance}{time}$$

(ii) the relationship between force, mass and acceleration:

$$force = mass \times acceleration$$

$$acceleration = \frac{change\ in\ velocity}{time\ \ taken}$$

(iii) the relationship between density, mass and volume:

$$density = \frac{mass}{volume}$$

(iv) the relationship between force, distance and work:

$$work\ done = force \times distance\ moved\ in\ direction\ of\ force$$

(v) the energy relationships:

$$energy\ transferred = work\ done$$

$$kinetic\ energy = \tfrac{1}{2} \times mass \times speed^2$$

$$change\ in\ potential\ energy = mass \times gravitational\ field\ strength \times change\ in\ height$$

(vi) the relationship between mass, weight and gravitational field strength:

$$weight = mass \times gravitational\ field\ strength$$

(vii) the relationship between an applied force, the area over which it acts and the resulting pressure:

$$pressure = \frac{force}{area}$$

(viii) the relationship between the moment of a force and its distance from the pivot:

moment = force × perpendicular distance from pivot

(ix) the relationships between charge, current, voltage, resistance and electrical power:

charge = current × time

voltage = current × resistance

electrical power = voltage × current

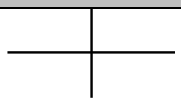
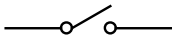
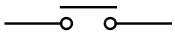
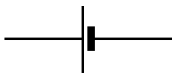
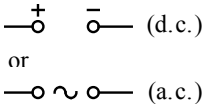
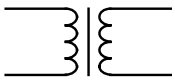
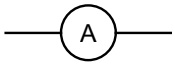
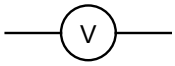
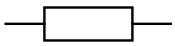
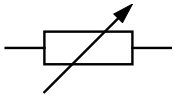
(x) the relationship between speed, frequency and wavelength:

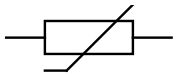
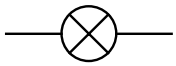
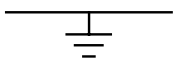
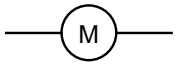
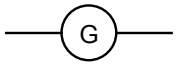
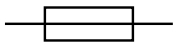
wave speed = frequency × wavelength

(xi) the relationship between the voltage across the coils in a transformer and the number of turns in them:

$$\frac{\textit{voltage across secondary}}{\textit{voltage across primary}} = \frac{\textit{number of turns in secondary}}{\textit{number of turns in primary}}$$

Appendix 7 – Electrical circuit symbols

Description	Symbol
conductors crossing with no connection	
junction of conductors	
open switch	
closed switch	
open push switch	
closed push switch	
cell	
battery of cells	
power supply	
transformer	
ammeter	
milliammeter	
voltmeter	
fixed resistor	
variable resistor	

Description	Symbol
heater	
thermistor	
light-dependent resistor (LDR)	
relay	
diode	
light-emitting diode (LED)	
lamp	
loudspeaker	
microphone	
electric bell	
earth or ground	
motor	
generator	
fuse/circuit breaker	

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